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The USDA/ERS Computable General Equilibrium (CGE) Model of the United States

Sherman Robinson
Maureen Kilkenny
Kenneth Hanson
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Abstract

This paper documents the basic Computable General Equilibrium (CGE) model of the U.S. economy developed at the Economic Research Service (ERS), USDA. The paper both describes the model equations in detail and how the model is "benchmarked" to a base data set. The paper also lists the computer program used to implement the model. The objective of the CGE work program at ERS is to provide a multisectoral framework for analyzing the effect of changes in agricultural policies and exogenous shocks on the farm sector, on the rural economy, on related nonagricultural sectors, and on the rest of the economy. The basic model has provided a starting point for a variety of extensions and applications exploring a number of policy issues. To date, work has largely focused on issues of agricultural trade policy and the effect of alternative domestic policies.

Keywords: Computable general equilibrium (CGE) model of the U.S. economy, social accounting matrix (SAM) of the U.S. economy, and GAMS modeling software.

The Authors

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Acknowledgments

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The USDA/ERS
Computable General Equilibrium (CGE)
Model of the United States

Sherman Robinson
Maureen Kilkenny
Kenneth Hanson

Introduction

This paper documents a basic Computable General Equilibrium (CGE) model of the U.S. economy emphasizing agriculture and international trade. Different versions of the basic CGE model have been used at the USDA to investigate a number of policy issues. To date, work has focused on issues of trade policy. A 10-sector version of the model has been used to analyze the impact of different proposals for liberalizing domestic and border policies concerning agriculture that have been suggested as part of the current negotiations in the Uruguay Round (1986-90) of the General Agreement on Tariffs and Trade (GATT).

An early version of the model was also used to analyze the impact on the structure of the U.S. economy of macro shocks in the 1982-86 period by Adelman and Robinson (1988). A different version of the same model was also used to analyze the impact on the economy of cutting defense expenditures by Roland-Holst, Robinson, and Tyson (1988). Work underway at the International Trade Commission to develop an in-house CGE modeling capability starting from the USDA model is discussed in Roland-Holst and Tokarick (1989).

Work is underway at the USDA to expand the model to include more sectoral detail and to extend the specification in new directions. The objective is to provide a multisectoral...
framework for analyzing the impact of changes in agricultural policies and exogenous shocks on the farm sector, on the rural economy, on related nonagricultural sectors, and on the rest of the economy.

The USDA CGE model is part of a long tradition of CGE models of the United States. These models focused on issues such as public finance, energy, industrial trade, the impact of import quotas, and the costs of pollution control. Examples include: Ballard, Fullerton, Shoven, and Whalley (1985); Hertel and Tsigas (1988); Hudson and Jorgenson (1974); Shoven and Whalley (1984); de Melo and Tarr (forthcoming); Goulder and Eichengreen (1989); and Jorgenson and Wilcoxen (1989).

A variety of approaches have been used to implement CGE models. The USDA model is implemented using a software package called GAMS (General Algebraic Modeling System). The GAMS software represents an important advance in implementing CGE models because its algebraic language provides a concise way to specify model equations. The GAMS program provides complete model documentation, and the model specification is independent of the solution algorithm. In the past, modelers developed their own application-specific software, which made the models difficult or impossible to transfer to others. A CGE model written in the GAMS equation language can be run on a wide variety of computers, including PC's.

The next two sections provide a brief description of the CGE model and its overall structure in a social accounting framework. A complete description of the model equations is presented in the section following these two sections. We then discuss how the model is calibrated using data from a balanced Social Accounting Matrix (SAM) for the U.S. economy, and describe how we implement the model in the GAMS software. Finally, we discuss applications, variations, and alternative model specifications.

**Major Features of the CGE Model**

A CGE model simulates the working of a market economy in which prices and quantities adjust to clear markets for products and factors. The model specifies the behavior of optimizing consumers and producers in the market economy. It also includes the government as an explicit agent (although not an optimizer) and captures all transactions in the circular flow of income.

The model is constructed to focus on issues of international trade and incorporates imperfect substitution between imports and domestic goods in demand. There is a parallel treatment of export supply, with imperfect transformability between production

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4 The GAMS package is described in detail in Brooke, Kendrick, and Meeraus (1988). The first CGE model implemented in GAMS was a model of Cameroon described in Condon, Dahl, and Devarajan (1987).
for domestic and foreign markets at the sectoral level. These features are characteristic of a large number of CGE models applied to developing countries to study issues of structural adjustment. The theoretical properties of this model with "semitradables" have been extensively documented, and it can be seen as an extension of the Salter-Swan "Australian" trade model, which incorporates nontraded goods.

This treatment of exports and imports realistically insulates the domestic price system from changes in world prices of sectoral substitutes. The model also makes the "small country" assumption on the import side, assuming that the United States cannot affect world prices of its imports. On the export side, we assume downward sloping world demand functions for some U.S. agricultural commodities. All other exports have fixed world prices.

Each sector produces a composite commodity that can be transformed into an export or a commodity sold on the domestic market. Each industry's output is produced according to a production function which uses primary and intermediate inputs. Sectoral input demands are derived from first order conditions for profit maximization.

Two modes of market behavior for primary factors (labor, capital, and land) may be modeled. In a "shortrun" version, capital is assumed to be sectorally fixed, and the final equilibrium will have sectorally differentiated rental rates. In a "longrun" version, all factors are mobile and average factor returns adjust to clear factor markets with full employment.

Aggregate domestic demand in the model has four components: consumption, intermediate demand, government, and investment (including inventory change). Household expenditure functions are derived from utility maximization. Each household pays income taxes to the government and saves a proportion of its income. Intermediate demand is given by fixed input-output coefficients. For the government, aggregate real spending on goods and services is exogenous. Inventory demand by sector is a fixed proportion of domestic output. The model distinguishes fixed investment by sector of destination and demand for investment goods by sector of origin. Investment demand by sector of origin is translated from investment demand by sector of destination by using a capital composition matrix.

The CGE model includes the major macro balances: savings-investment, government deficit, and the balance of trade.

5For surveys of this literature, see Robinson (1989a,b) and de Melo (1988). There are also a number of multi-country CGE models. For a survey, see Shoven and Whalley (1984).

Aggregate investment is either set exogenously from a macro model or is "savings driven." Aggregate savings is the sum of enterprise-retained earnings plus capital consumption allowance, household saving, government saving, and foreign saving. Government saving is the difference between revenue and spending. Alternative approaches to reconciling aggregate savings and investment are discussed below.

In the balance of trade equation, the value of imports at world prices must equal the value of exports at world prices plus foreign savings, net remittances, and net foreign borrowing by the U.S. Government. Two alternative equilibrating mechanisms are possible. First, the balance of trade is specified exogenously and the real exchange rate adjusts to achieve equilibrium. Second, the exchange rate is exogenous and the balance of trade is assumed to adjust.

The CGE model solves only for relative prices. We choose as the numeraire price index the GNP price deflator. Given the choice of numeraire, the model solves for all relative factor returns and prices that clear the markets for factors and products. The model also solves for the equilibrium value of the real exchange rate, given the exogenously set balance of trade.

**SAM Structure of the Model**

A Social Accounting Matrix (SAM) provides a tabular snapshot of the economy at one point in time. Figure 1 presents a descriptive SAM for the United States that shows the transactions among agents in the economy captured in the CGE model. The structure of the SAM is consistent with the U.S. National Income and Product Accounts (NIPA). The treatment of exports as a delivery from activities to the rest of the world, rather than going through the commodity account, reflects the model's specification of producers as "transforming" goods for delivery to the domestic and export markets. This treatment has the added advantage of making the commodity account in the SAM measure the trade-theory notion of "absorption," or total supply of goods to the domestic economy.

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7For an introduction to Social Accounting Matrices, see King (1985) and United Nations (1968). The seminal work was done by Richard Stone and is described in Stone (1986). Pyatt and Round (1985) provide a number of examples of the uses of SAM's. Hanson and Robinson (1989) provide the mapping for the United States from the NIPA to a SAM framework.

8In the U.S. input-output accounts, exports are part of the commodity account. A "make" matrix is used to transform activities to commodities, with all intermediate and final demands (including exports) specified as demands for commodities. Our treatment, separating export and domestic demand, is consistent with our modeling perspective.
Figure 1--A Descriptive Social Accounting Matrix (SAM)

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Commodity Activity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Row totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers</td>
<td></td>
<td>Suppliers</td>
<td>1</td>
<td>Co commodity</td>
<td>intermediate demand</td>
<td>household</td>
<td>government</td>
<td>investment</td>
<td>purchases</td>
<td>domestic sales</td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Suppliers</td>
<td>2</td>
<td>Activity</td>
<td>domestic supply</td>
<td>consumption</td>
<td>purchases</td>
<td>export</td>
<td>subsidies</td>
<td>exports</td>
<td>total sales</td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Value added</td>
<td>3</td>
<td>Labor</td>
<td>employee compensation</td>
<td>household</td>
<td>government</td>
<td>investment</td>
<td>purchases</td>
<td>domestic sales</td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Value added</td>
<td>4</td>
<td>Capital</td>
<td>capital income</td>
<td>consumption</td>
<td>purchases</td>
<td>export</td>
<td>subsidies</td>
<td>exports</td>
<td>total sales</td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Institutional actors</td>
<td>5</td>
<td>Enterprise</td>
<td>gross bus. income</td>
<td>household</td>
<td>government</td>
<td>investment</td>
<td>purchases</td>
<td>domestic sales</td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Institutional actors</td>
<td>6</td>
<td>Household</td>
<td>labor income</td>
<td>distributed</td>
<td>profits</td>
<td>transfers</td>
<td>to bus.</td>
<td>enterprise income</td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Institutional actors</td>
<td>7</td>
<td>Government</td>
<td>tariff indirect tax</td>
<td>social security tax</td>
<td>associated</td>
<td>business</td>
<td>household</td>
<td>net foreign remittances</td>
<td>household income</td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Institutional actors</td>
<td>8</td>
<td>Capital</td>
<td>bus. savings +depreciation</td>
<td>household</td>
<td>government</td>
<td>net foreign</td>
<td>transfers</td>
<td>total savings</td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td>Institutional actors</td>
<td>9</td>
<td>World</td>
<td>imports</td>
<td>associated</td>
<td>business</td>
<td>household</td>
<td>government</td>
<td>net foreign</td>
<td>foreign income</td>
</tr>
</tbody>
</table>

Absorption costs: total employee compensation income

Expenditure expenditure expenditure expenditure expenditure investment expenditure
Each nonzero cell in the SAM represents the value of an economic transaction between actors. The model equations describe every entry in the SAM. The accounts in the SAM effectively define the transactions and income flows among five basic actors in the economy: suppliers/enterprises, households, government, capital account, and rest of world. A row documents the income to an account, the corresponding column documents the outflow, and the row and column sums must balance for each account. In equilibrium, this balance implies: (1) costs (plus distributed earnings) exhaust revenues for producers, (2) expenditure (plus taxes and savings) equals income for each agent in the model, and (3) demand equals supply of each commodity.

The first two rows and columns of the SAM capture the workings of the product and factor markets. The row of the commodity account describes the domestic product market, with the supply to domestic users. The column of the commodity account keeps track of absorption, which equals the value of domestic products sold on the domestic market, and imports, including tariffs.

Column two describes the demand for factors of production and intermediate inputs. Producers pay out value added to factors and indirect taxes to government down the column, and sell goods on the domestic and foreign markets along the row. Export subsidies are seen as a payment by government to producers. Exports and imports in the account for the rest of the world are valued in world market prices times the exchange rate.

The next two rows and columns (3 and 4) describe the payment of value added to primary factors and its distribution to institutional actors. The last five rows and columns (5 to 9) describe inter-institutional transfers and the generation of demand for goods in the product markets. The last three accounts (7 to 9) capture the major macro balances: government deficit, savings-investment, and balance of trade.

Three types of transactions occur among the actors. First, there are "market transactions," with goods and services (including factor services) flowing from rows to columns and corresponding payments flowing from columns to rows. These are given in the first two rows and columns of the SAM plus the last row and column. Second, there are "transfers," either voluntary or involuntary, involving nominal flows from column accounts but no real flows from the row accounts. Accounts 3 to 7 involve this type of transaction, essentially mapping the flow of funds in the economy. Tax payments can be viewed as involuntary transfers, while the rest can be seen as voluntary.

Finally, there are "financial transactions." In the SAM, these are all captured in the single "capital" account, which summarizes the workings of all financial markets. This account collects savings from the various actors along the row and uses the proceeds to purchase capital goods ("investment") in cell (1,8). In the capital account row, agents presumably receive title to assets in return for depositing their savings. Financial transactions in the capital account implicitly define
the market for new assets, with the supply of new assets equaling the value of aggregate investment. The CGE model, however, is defined only in terms of flows and determines a flow equilibrium for a single period. The model has no assets, money, interest rates, expectations, or dynamics.

Equations of the CGE Model

The order of the presentation of the equations follows the generation and flow of income from producers to households. First, we present equations defining the price system, followed by equations describing production and the generation of value added. The next block of equations describes the mapping of value added into institutional income. The following block completes the circular flow, describing the demand for goods by the various actors. Finally, there are a number of "system constraints" that the model economy must satisfy. These include market-clearing conditions and macro "closure" equations. A summary table of all the equations is provided in Appendix 1.

In the basic model, the U.S. economy is disaggregated into 10 sectors. There are three primary factors of production, three categories of households, and three "institutions" which serve as intermediaries in mapping factor income to household income. Table 1 lists the various indices, describes the sets they represent, and presents the definitions of all variables and parameters. Tables 2 through 6 list the model equations as they are described. Following the equation number in these tables is an index, or number, for counting equations. The counting of equations and variables is tabulated in table 7.

GAMS notation is used throughout this section. While close to standard algebra, GAMS has some differences. There are a few differences in operator notation. The summation operator is written "SUM," with the index of summation and the arguments written in parentheses separated by a comma. For example: \( \sum_i X_i \) is written \( \text{SUM}(i, X(i)) \) in GAMS. The product operator is "PROD," and the algebraic expression \( \prod_i X_i \) is written \( \text{PROD}(i, X(i)) \). The GAMS language allows a great deal of flexibility in describing equations, including inequalities and Boolean relationships. We do not need these extensions in the presentation of the basic model equations. Some are used in the listing of the GAMS version of the model given in Appendix 2.

Some notational conventions are followed consistently. Endogenous variables are presented in upper case, while parameters, exogenous variables, and indices are always lower case. In a few equations, an index is replaced by a specific entry (given in quotes).
Table 1—Definitions of indices, variables, and parameters

<table>
<thead>
<tr>
<th>Indices</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i, j</td>
<td>Sectors</td>
<td></td>
</tr>
<tr>
<td>im</td>
<td>Sectors with imports</td>
<td></td>
</tr>
<tr>
<td>imm</td>
<td>Sectors without imports: im + imm = i</td>
<td></td>
</tr>
<tr>
<td>ie</td>
<td>Sectors with exports</td>
<td></td>
</tr>
<tr>
<td>ien</td>
<td>Sectors without exports: ie + ien = i</td>
<td></td>
</tr>
<tr>
<td>ied</td>
<td>Sectors with world export demand functions</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>Factors of production: labor, capital, and land</td>
<td></td>
</tr>
<tr>
<td>ins</td>
<td>Institutions: labr, prop, and ent (Labor, property, and enterprises)</td>
<td></td>
</tr>
<tr>
<td>hh</td>
<td>Households</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices block</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXR</td>
<td>Exchange rate</td>
<td></td>
</tr>
<tr>
<td>P(i)</td>
<td>Price of composite good</td>
<td></td>
</tr>
<tr>
<td>PD(i)</td>
<td>Domestic sales price</td>
<td></td>
</tr>
<tr>
<td>PE(i)</td>
<td>Domestic price of exports</td>
<td></td>
</tr>
<tr>
<td>PINDEX</td>
<td>GNP deflator</td>
<td></td>
</tr>
<tr>
<td>PX(i)</td>
<td>Price of a unit of capital in each sector</td>
<td></td>
</tr>
<tr>
<td>PM(i)</td>
<td>Domestic price of imports</td>
<td></td>
</tr>
<tr>
<td>PVA(i)</td>
<td>Value-added price</td>
<td></td>
</tr>
<tr>
<td>PWE(i)</td>
<td>World price of exports</td>
<td></td>
</tr>
<tr>
<td>F(i)</td>
<td>Output price</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production block</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E(i)</td>
<td>Exports</td>
<td></td>
</tr>
<tr>
<td>FDSC(i,f)</td>
<td>Factor demand</td>
<td></td>
</tr>
<tr>
<td>INT(i)</td>
<td>Intermediate input demand</td>
<td></td>
</tr>
<tr>
<td>M(i)</td>
<td>Imports</td>
<td></td>
</tr>
<tr>
<td>WF(f)</td>
<td>Average factor price</td>
<td></td>
</tr>
<tr>
<td>X(i)</td>
<td>Composite goods supply</td>
<td></td>
</tr>
<tr>
<td>XD(i)</td>
<td>Domestic output</td>
<td></td>
</tr>
<tr>
<td>XXD(i)</td>
<td>Domestic sales</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income and expenditure blocks</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CD(i)</td>
<td>Final demand for private consumption</td>
<td></td>
</tr>
<tr>
<td>DEPRECIA</td>
<td>Total depreciation charges</td>
<td></td>
</tr>
<tr>
<td>DK(i)</td>
<td>Fixed investment by sector of destination</td>
<td></td>
</tr>
<tr>
<td>DST(i)</td>
<td>Inventory investment by sector</td>
<td></td>
</tr>
<tr>
<td>ENTSAV</td>
<td>Enterprise savings</td>
<td></td>
</tr>
<tr>
<td>ENTTAX</td>
<td>Enterprise tax revenue</td>
<td></td>
</tr>
<tr>
<td>FBOR</td>
<td>Net foreign borrowing</td>
<td></td>
</tr>
<tr>
<td>FXDIV</td>
<td>Fixed capital investment</td>
<td></td>
</tr>
<tr>
<td>PSAV</td>
<td>Foreign savings</td>
<td></td>
</tr>
<tr>
<td>GD(i)</td>
<td>Final demand for government consumption</td>
<td></td>
</tr>
<tr>
<td>GDTOT</td>
<td>Aggregate real government consumption</td>
<td></td>
</tr>
<tr>
<td>GENT</td>
<td>Transfer payments from government to enterprises</td>
<td></td>
</tr>
<tr>
<td>GNPVA</td>
<td>Nominal GNP or value added in market prices</td>
<td></td>
</tr>
<tr>
<td>GOVSAV</td>
<td>Government savings</td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>Total government revenue</td>
<td></td>
</tr>
<tr>
<td>HHSAV</td>
<td>Total household savings</td>
<td></td>
</tr>
<tr>
<td>HHT</td>
<td>Government transfer payments to households</td>
<td></td>
</tr>
<tr>
<td>ID(i)</td>
<td>Final demand for investment goods</td>
<td></td>
</tr>
<tr>
<td>INDTAX</td>
<td>Total indirect tax revenue</td>
<td></td>
</tr>
</tbody>
</table>

Continued—
Table 1--Definitions of indices, variables, and parameters--Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INVEST</td>
<td>Total investment</td>
</tr>
<tr>
<td>NETSUB</td>
<td>Total export subsidies</td>
</tr>
<tr>
<td>REMIT</td>
<td>Net remittances from abroad</td>
</tr>
<tr>
<td>RGNF</td>
<td>Real GNP</td>
</tr>
<tr>
<td>SAVINGS</td>
<td>Total savings</td>
</tr>
<tr>
<td>SSTAX</td>
<td>Social security tax revenue</td>
</tr>
<tr>
<td>TARIFF</td>
<td>Tariff revenue</td>
</tr>
<tr>
<td>TOTHTAX</td>
<td>Household tax revenue</td>
</tr>
<tr>
<td>YFCTR(f)</td>
<td>Factor income</td>
</tr>
<tr>
<td>YH(hh)</td>
<td>Household income</td>
</tr>
<tr>
<td>YINST(ins)</td>
<td>Institutional income</td>
</tr>
<tr>
<td>ac(im)</td>
<td>CES function shift parameter</td>
</tr>
<tr>
<td>ad(i)</td>
<td>Production function shift parameter</td>
</tr>
<tr>
<td>alpha(i,f)</td>
<td>Share parameter in production function</td>
</tr>
<tr>
<td>at(ie)</td>
<td>CET function shift parameter</td>
</tr>
<tr>
<td>cles(i,hh)</td>
<td>Household expenditure shares</td>
</tr>
<tr>
<td>delta(im)</td>
<td>CES function share parameter</td>
</tr>
<tr>
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<td>econst(ied)</td>
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<td>etr</td>
<td>Enterprise tax rate</td>
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<td>Aggregate factor supply</td>
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<td>gamma(ie)</td>
<td>CET function share parameter</td>
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<td>Household saving rate</td>
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<td>Tariff rate on imports</td>
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<td>tmreal(im)</td>
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<tr>
<td>wfdist(i,f)</td>
<td>Factor market distortion parameters</td>
</tr>
</tbody>
</table>
Table 2 -- Price equations

(1) \[ im \quad PM(im) = pwm(im) \ast (1 + tm(im)) \ast EXR \]
(2) \[ ie \quad PE(ie) = PWE(ie) \ast (1 + te(ie)) \ast EXR \]
(3) \[ i \quad P(i) = (PD(i) \ast X XD(i) + PM(i) \ast M(i)) / X(i) \]
(4) \[ i \quad PX(i) = (PD(i) \ast X XD(i) + PE(i) \ast E(i)) / XD(i) \]
(5) \[ i \quad PVA(i) = PX(i) \ast (1 - itax(i)) - \sum(j, io(j,i) \ast P(j)) \]
(6) \[ i \quad PK(i) = \sum(j, P(j) \ast imat(j,i)) \]
(7) \[ l \quad PINDEX = GNPVA / RGNP \]

**Price Equations**

Table 2 presents the model's price system. On the import side, the model incorporates the "small country" assumption: world prices (pwm) are exogenous. The domestic price of imports (PM) is simply the tariff-ridden world price times the exchange rate (EXR). On the export side, for some agricultural sectors, there is assumed to be a downward-sloping world demand curve for U.S. exports. For these sectors, the world price (PWE) is endogenous. The domestic price of exports, PE, includes any export subsidies.

Equations 3 and 4 describe the prices for the composite commodities X and XD. These equations reflect the homogeneity of the import aggregation and export transformation functions. The value of the composites must equal the value of their component parts, regardless of functional form. We discuss below the properties of the functions.9

Equation 5 defines the sectoral value-added or "net" price (PVA). It equals the output price minus indirect taxes and the cost of intermediate inputs (given fixed input-output coefficients).10 The expression PVA \cdot XD equals sectoral value added (at factor cost), which is paid to primary factors.

Equation 6 gives the price (PK) of a unit of capital installed in sector i. PK differs across sectors, reflecting the fact that capital used in different sectors is heterogeneous. The composition of capital goods used by a sector (by sector of origin) is given by the columns of the matrix imat. Because each column of imat sums to one, PK(i) is simply the weighted average of the costs of capital goods used in sector i.

Finally, equation 7 defines an aggregate price index (PINDEX), which is the GNP deflator. It equals nominal GNP (GNPVA) divided

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9 In some models, it is convenient to use the dual price equations and drop the CES aggregation and CET transformation functions. For these functions, the two treatments are equivalent. When using flexible functional forms that are not self-dual, alternative treatments can matter.

10 Note that indirect tax rates are computed on a base of PX. In other models, they are computed on a base of PD. See, for example, Devarajan, Lewis, and Robinson (1990).
by real GNP (RGNP). This is the numeraire price index that will be fixed, defining the absolute price level against which all relative prices will be measured. The GNP deflator is a convenient choice, but any other price index could be used. Other common choices in CGE models include a consumer or producer price index, the exchange rate, or the wage.

### Quantity Equations

Table 3 gives the block of quantity equations, which effectively determine the supply side of the model. Equations 8 to 10 define the production technology and sectoral demand for factors. Equations 11 to 13 give the export transformation functions and the corresponding export supply functions, which depend on relative prices (PE/PD). Equation 14 gives the world demand functions for exports in sectors in which the United States is assumed to face a downward-sloping world demand curve (indexed by ied). Equations 15 to 17 give the import aggregation functions and the corresponding import demand functions, which depend on relative prices (PD/PM).

Equation 8 defines a Cobb-Douglas value-added production function with primary factors FDSC (including labor, capital, and land). The demand for intermediate inputs is given by equation 10, which assumes fixed input-output coefficients. The demand for primary factors, equation 9, reflects the first-order conditions for profit maximization using the value-added price, PVA. Given that the value-added price appears in equation 9, there is no need to define a separate variable for real value added. Consequently, XD appears in equations 8 and 9.

The model will solve for average factor prices, WF(f), that clear the factor markets. The model also allows for factor-market distortions. The parameters wfdist(i,f) are assumed fixed and

### Table 3--Quantity equations

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
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<tbody>
<tr>
<td>(8) i XD(i) = ad(i)*PROD(f, FDSC(i,f)**alpha(i,f))</td>
<td>Equation defining the production technology</td>
</tr>
<tr>
<td>(9) i,f WF(f)*wfdist(i,f) = PVA(i)*alpha(i,f)*XD(i)/FDSC(i,f)</td>
<td>Equation defining the demand for primary factors</td>
</tr>
<tr>
<td>(10) i INT(i) = SUM(j, io(i,j)*XD(j))</td>
<td>Equation defining the demand for intermediate inputs</td>
</tr>
<tr>
<td>(11) ie XD(ie) = at(ie)*(gamma(ie)*E(ie)**rhot(ie) + (1-gamma(ie))*XXD(ie)<strong>rhot(ie))</strong>(1/rhot(ie))</td>
<td>Equation defining the export transformation function</td>
</tr>
<tr>
<td>(12) ien XD(ien) = XXD(ien)</td>
<td>Equation defining the export supply function</td>
</tr>
<tr>
<td>(13) ie E(ie) = XXD(ie)<em>(PE(ie)/PD(ie))</em>(1 - gamma(ie))**(1/(rhot(ie)-1))</td>
<td>Equation defining the world demand function for exports</td>
</tr>
<tr>
<td>(14) ied E(ied) = econst(ied)*((PWE(ied)/pwe(ied))**(-rhoe(ied)))</td>
<td>Equation defining the import aggregation function</td>
</tr>
<tr>
<td>(15) im X(im) = ac(im)*(delta(im)*M(im)<strong>(-rhoc(im)) + (1-delta(im))*XXD(im)</strong>(-rhoc(im))**(1/rhoc(im)))</td>
<td>Equation defining the import demand function</td>
</tr>
<tr>
<td>(16) imn X(imn) = XXD(imn)</td>
<td>Equation defining the export supply function for imports</td>
</tr>
<tr>
<td>(17) im M(im) = XXD(im)<em>((PD(im)/PM(im))</em>(delta(im)/(1-delta(im))))**(1/(1+rhoc(im)))</td>
<td>Equation defining the import demand function for imports</td>
</tr>
</tbody>
</table>
measure the extent to which the marginal revenue product of a factor in a particular sector deviates from the average return for that factor across the economy. If there are no distortions in the factor markets, all the wfdist(i,f) parameters will equal one.

Total domestic production (XD) is supplied to domestic (XXD) or foreign (E) markets. The three goods are distinct, with separate prices, although they have the same sectoral classification. In effect, each sector is a two-product firm, producing goods for the export and domestic market. Equation 11 describes how sectoral production is transformed into goods for domestic markets and export markets.

The functional form of equation 11 is a constant elasticity of transformation (CET) function. Producers maximize revenue from sales subject to the CET transformation function. Export supply, equation 13, represents the first-order conditions and is a function of the relative export price to domestic price, the elasticity of transformation between the two uses, and the share parameters in the CET function.

Imported (M) and domestic goods (XXD) are also distinct, with separate sectoral prices. Consumers demand a composite good, which is a CES aggregate of imported and domestic goods with the same sectoral classification (equation 15). Import demand is given by equation 17, which is the first order condition for minimizing the cost of buying a given amount of composite good. The model thus allows cross-hauling (that is, simultaneous exports and imports) at the sectoral level.11

This treatment of exports and imports partially insulates the domestic price system from changes in world prices of sectoral substitutes. The specification of imperfect substitution and transformation is more realistic than the extreme dichotomy between perfect substitutes and nontraded goods commonly specified in analytic trade models. The particular functional forms used (CES and CET functions) embody strong assumptions about separability and the absence of income effects. The ratio of exports and imports to domestic sales at the sectoral level depends only on relative prices, with no income effects. These strong assumptions can be weakened without losing the fundamental assumption that domestic and foreign goods are imperfect substitutes. Hanson, Robinson, and Tokarick (1990), for example, specify import demand according to a flexible functional form, the Almost Ideal Demand System (AIDS). The AIDS system allows for a non-unitary income elasticity of demand for imports at the sectoral level.

11The model also allows pure nontraded goods. In sectors with no exports or imports (indices ien and imn), the aggregation functions are not needed (equations 12 and 16).
Table 4—Income equations

(18) \( \text{YFCTR}(f) = \sum \text{WF}(i, f) \times \text{wdist}(i, f) \times \text{FDSC}(i, f) \)

(19) \( \text{YINST("labr")} = \text{YFCTR("labor")} - \text{SSTAX} \)

(20) \( \text{YINST("prop")} = \text{YFCTR("land")} \)

(21) \( \text{YINST("ent")} = \text{YFCTR("capital")} + \text{GENT} - \text{ENTSAV} - \text{ENTTAX} - \text{DEPRECIA} \)

(22) \( \text{YH}(hh) = \sum \text{sintyh}(hh, ins) \times \text{YINST}(ins) \)

(23) \( \text{TARIFF} = \sum \text{tm}(im) \times \text{pwm}(im) \times \text{M}(im) \times \text{EXR} \)

(24) \( \text{INDTAX} = \sum \text{itax}(i) \times \text{PX}(i) \times \text{XD}(i) \)

(25) \( \text{NETSUB} = \sum \text{te}(ie) \times \text{PWE}(ie) \times \text{E}(ie) \times \text{EXR} \)

(26) \( \text{SSTAX} = \text{sstr} \times \text{YFCTR("labor")} \)

(27) \( \text{ENTTAX} = \text{etr} \times \text{YFCTR("capital")} - \text{DEPRECIA} + \text{GENT} \)

(28) \( \text{TOTHHTAX} = \sum \text{hhtax}(hh) \times \text{YH}(hh) \)

(29) \( \text{DEPRECIA} = \sum \text{depr}(i) \times \text{PK}(i) \times \text{FDSC}(i, \text{"capital")} \)

(30) \( \text{ENTSAV} = \text{esr} \times \text{YFCTR("capital")} + \text{GENT} - \text{ENTTAX} - \text{DEPRECIA} \)

(31) \( \text{HHSAV} = \sum \text{mps}(hh) \times \text{YH}(hh) \times (1 - \text{htax}(hh)) \)

(32) \( \text{GR} = \text{TARIFF} - \text{NETSUB} + \text{INDTAX} + \text{TOTHHTAX} + \text{SSTAX} + \text{ENTTAX} + \text{FBOR} \times \text{EXR} \)

(33) \( \text{SAVINGS} = \text{HHSAV} + \text{GOVSAV} + \text{DEPRECIA} + \text{FSAV} \times \text{EXR} + \text{ENTSAV} \)

Income Equations

Table 4 presents the equations that map the flow of income from value added to institutions and ultimately to households. Factor incomes (YFCTR) are defined in equation 18. They are mapped into institutional incomes (YINST) in equations 19 to 21, net of institutional taxes, savings, and government transfers. Using fixed allocation shares (sintyh), institutional income is distributed to households in equation 22. Households also receive income as remittances from abroad (generally negative for the United States) and transfers from the government. Taxes are determined in equations 23 to 28, and total government revenue is given in equation 32. Savings, including depreciation charges, are given in equations 29 to 31 and are summed in equation 33.

These income equations serve to fill out all the inter-institutional entries in the SAM. Many of these entries will be specific to the institutional structure of a particular country. For example, government revenue includes a term FBOR \times \text{EXR}. In the U.S. accounts, this variable is net foreign transfers received by the U.S. Government (generally negative for the United States), minus net interest paid by the Government to foreigners on outstanding official debt. While they are listed as variables, many of these items will be set exogenously in the model or determined by simple share or multiplier parameters.
Table 5--Expenditure and equilibrium equations

Expenditure equations:

\[ (34) \quad i \quad P(i) \cdot CD(i) = \text{SUM}(hh, cles(i, hh) \times (1 - mps(hh)) \times YH(hh)) * (1 - htax(hh)) \]
\[ (35) \quad i \quad GD(i) = gles(i) \times \text{GDTOT} \]
\[ (36) \quad i \quad DST(i) = dstr(i) \times XD(i) \]
\[ (37) \quad i \quad FXDINV = \text{INVEST} - \text{SUM}(i, DST(i) \times P(i)) \]
\[ (38) \quad i \quad FK(i) \times DK(i) = kish(i) \times FXDINV \]
\[ (39) \quad i \quad ID(i) = \text{SUM}(j, imat(i, j) \times DK(j)) \]
\[ (40) \quad i \quad GNPVA = \text{SUM}(i, PVA(i) \times XD(i)) + \text{INDTAX} + \text{TARIFF} - \text{NETSUB} \]
\[ (41) \quad i \quad RGNP = \text{SUM}(i, CD(i) + DST(i) + ID(i) + GD(i)) + \text{SUM}(ie, (1 - tereal(ie)) \times E(ie)) - \text{SUM}(im, (1 - tmreal(im)) \times M(im)) \]

Equilibrium equations:

\[ (42) \quad i \quad X(i) = \text{INT}(i) + CD(i) + GD(i) + ID(i) + DST(i) \]
\[ (43) \quad f \quad \text{SUM}(i, FDSC(i, f)) = fs(f) \]
\[ (44) \quad i \quad GR = \text{SUM}(i, P(i) \times GD(i)) + \text{GOVSAV} + \text{GENT} + \text{HHT} \]
\[ (45) \quad i \quad \text{SUM}(im, pwm(im) \times M(im)) = \text{SUM}(ie, PWE(ie) \times E(ie)) + \text{FSAV} + \text{REMIT} + \text{FBOR} \]
\[ (46) \quad i \quad \text{SAVINGS} = \text{INVEST} \]

Expenditure and Equilibrium Equations

Table 5 gives equations that complete the circular flow of income and expenditure, determining the demands for goods by the various actors. Consumer expenditures, equation 34, are a function of prices and income according to a simplified version of the Linear Expenditure System (LES).\(^{12}\) Government demand for final goods, equation 35, is defined in terms of fixed shares (gles parameter) of aggregate real government spending on goods and services (GDTOT). Equation 44 is the government balance equation, equating revenue and expenditure (including the deficit).

Equations 36 to 39 determine the demand for capital goods. The demands for new inventories (DST) are given by fixed coefficients times production (equation 36). Aggregate nominal fixed investment (FXDINV) equals total nominal investment (INVEST) minus the value of inventory accumulation (equation 37). Equation 38 determines fixed real investment by sector of destination (DK). The allocation of nominal fixed investment to sectors is given by fixed shares (kish), which sum to one over all sectors. Equation 39 translates investment by sector of destination into demand for capital goods by sector of origin, using the capital composition matrix (imat). Given the

\(^{12}\)In this case, all subsistence minima are set to zero. The LES reduces to fixed expenditure shares and a Cobb-Douglas utility function.
definition of PK(i), that \( \text{SUM}(i, \text{kish}(i)) = 1 \), and that
\( \text{SUM}(i, \text{imat}(i,j)) = 1 \) for all \( j \), then it will be true that:

\[
\text{FXDINV} = \text{SUM}(i, \text{PK}(i) \cdot \text{DK}(i)) = \text{SUM}(i, \text{P}(i) \cdot \text{ID}(i)).
\]

The basic CGE model is static, with the economywide capital stock
specified as an exogenous variable. The model does generate
savings, investment, and demands for capital goods. The capital
goods, however, are assumed not to be installed during the
period, and so simply represent a separate demand category. In a
dynamic model, the assumption of heterogeneity of capital goods
by sector of destination is very important, affecting the dynamic
properties of different growth paths. In a static model, the
assumption is less important, but does have some impact because
different assumptions about the composition of investment by
sector of destination will change the structure of demand. The
specification of PK as sectorally differentiated reflects this
assumption.\(^{13}\)

Equations 40 and 41 define real and nominal GNP, which are used
to define the GNP deflator in the price equation block. Defining
GNP from the expenditure side, imports are valued at world prices
times the exchange rate, net of tariffs. In defining value
added, imports are purchased by producers at domestic market
prices, which include tariffs. To make GNP calculated as the sum
of value added (at market prices) consistent with GNP calculated
from the expenditure side, tariffs must be added to total value
added, which is done in equation 40.\(^{14}\) In the definition of
real GNP, real imports are defined net of "real" tariffs, given
the real tariff rates \( \text{tmreal}(i) \).\(^{15}\)

In principle, exports should be treated symmetrically with
imports. In the national accounts, exports are valued at world
prices times the exchange rate, so that export subsidies need to
be netted out from the value added side, which is done in
equation 40. Note that, unlike tariffs, export subsidies are
distributed to producing sectors. In defining sectoral value
added at market prices, they can be treated symmetrically with
indirect taxes. Note also that \( \text{PVA} \), defined in equation 5,
includes export subsidies but excludes indirect taxes.\(^{16}\)

\(^{13}\)Other U.S. models that have focused on tax analysis have
all assumed that capital is not heterogeneous. See, for example,
Ballard, Fullerton, Shoven, and Whalley (1985). In such a model,
PK is a scalar and imat is a vector.

\(^{14}\)In the U.S. National Income and Product Accounts (NIPA),
tariffs are added to value added in the wholesale trade sector.
The United Nations system of national accounts (SNA) keeps
tariffs as a separate entry in the value added accounts.

\(^{15}\)This treatment is standard in national accounting, with
\( \text{tmreal}(i) \) defined as the tariff rates in the base year. Not all
countries define "real" tariffs this way. Some deflate nominal
tariffs by some deflator, say that for imports.

\(^{16}\)The \( \text{tmreal}(i) \) parameters are needed on the export side
because it is customary to define real magnitudes in the base
Equations 42 to 46 define the system constraints that the model economy must satisfy. The model is a general equilibrium system, with all endogenous variables being jointly determined. In discussing how the economy satisfies these system constraints, however, it is useful to think in terms of equilibrium conditions and equilibrating variables. In a competitive market economy, market clearing is achieved by varying prices, and it is helpful to identify the price associated with each market.

Equation 42 states that the sectoral supply of composite commodities must equal demand and defines market-clearing equilibrium in the product markets. There is also an analogous sectoral market-clearing condition for domestically produced goods sold on the domestic market (XXD). However, from equation 17, the ratio of imports to domestic sales is assumed to be the same for all categories of demand. Thus, at the sectoral level, specifying a separate market-clearing condition for domestically produced goods sold on the domestic market amounts to multiplying through both sides of equation 42 by the ratio XSD(i)/X(i). A separate equation for domestically produced goods sold on the domestic market is not needed. When the market for composite goods clears, then so will the market for domestic goods.

Equation 43 defines equilibrium in the factor markets. The supplies of primary factors (fs) are assumed fixed exogenously and are given as parameters. Market clearing requires that total factor demand equal supply. The equilibrating variables are the average factor prices, WF(f). In the model as specified, all factors are freely mobile, including capital. The model must be seen as defining a long-run equilibrium in which sectoral capital stocks have time to adjust, equating rental rates across sectors. An alternative approach is to specify a short-run model, with sectoral capital stocks fixed exogenously. Such a specification is easy to implement in the existing model structure. Fixing sectoral capital stocks amounts to making the FDSC(i,f) variables exogenous for the factor "capital." The corresponding factor market-clearing equation is redundant and can be dropped. With sectorally fixed capital stocks, however, it is not possible to assume that the rental rate will be the same across sectors. This condition can be relaxed in the model by simply specifying the wfd(i,"capital") parameters as endogenous variables

year such that PE(i) = 1, and we assume that PE is a subsidy-ridden price (see equation 2 in table 3). There is less consistency across countries in the treatment of export subsidies than in the treatment of tariffs. Many countries appear to value exports in their accounts at subsidy-ridden prices. Since export subsidies are forbidden under the GATT, national statistical agencies tend to assume they do not exist. In the United States, there were no export subsidies in 1982, the base year for the model.

With the wfd(i,"capital") parameters, sectoral rental rates are not equated, but may differ from the average by the fixed ratios.
instead of parameters, adding n new equilibrating variables, and dropping the average factor return variable. 18 This treatment allows all sectoral rental rates to be determined endogenously, given the fixed sectoral capital stocks.

Macroeconomic Closure

The income and expenditure equations capture the three major macro balances: savings-investment, government deficit, and the balance of trade. Because the model is closed in that it satisfies Walras' Law, the three macro balances will satisfy the identity: private savings + government savings + foreign savings = aggregate investment. The modeler must take care not to specify independent equations determining all of these components endogenously, because the resulting model will either not satisfy Walras' Law or be infeasible.

Equations 44 through 46 describe equilibrium conditions for the government deficit, balance of trade, and savings-investment balance. These can be seen as defining notions of macroeconomic equilibrium. Additional equations are required to define the equilibrating variables. Table 6 lists the conditions required, plus a few additional restrictions arising from the definition of traded sectors.

In this model, the government deficit is determined residually in equation 44. Equations 50 to 52 in table 6 fix government expenditure items, and GOVSNAV is the equilibrating variable. The second macro equilibrium condition, equation 45, concerns the balance of trade equation. In the model as presented, equations 47 to 49 fix all the financing items in the trade balance equation: net foreign savings, remittances, and net official borrowing (FSAV, REMIT, and FBOR). The result is that the balance of trade in goods and services is set exogenously in the model. 19 The equilibrating variable is the nominal exchange rate, EXR. The equilibrating mechanism at work is that, given the numeraire in equation 53, changes in EXR change the relative prices of nontradables (PD) and tradables (PE and PM)--the real exchange rate.

The CGE model determines an equilibrium relationship between the exchange rate and the balance of trade. For example, an increase in EXR implies a real depreciation, with the sectoral prices of tradables (PE and PM) rising relative to PD. Given the export supply and import demand equations, a real depreciation should lead to higher exports and lower imports. An alternative closure

18 In the GAMS program, a variable can be effectively dropped by fixing its value to one.
19 Note that since the model is based on the GNP accounts, trade in services includes factor services. Thus, the trade balance in this model is the current account balance. Many CGE models are based on the gross domestic product (GDP) accounts, with the balance of trade referring to goods and nonfactor services.
### Table 6--Macro closure equations

#### Balance of trade:

1. \( 1 \text{FSAV} = \text{fsav} \)  
2. \( 1 \text{REMIT} = \text{remit} \)  
3. \( 1 \text{FBOR} = \text{fbor} \)

#### Government balance:

1. \( 1 \text{GDTOT} = \text{gdtot} \)  
2. \( 1 \text{GENT} = \text{gent} \)  
3. \( 1 \text{HHT} = \text{hht} \)

#### Numeraire price index:

\( 1 \text{PINDEX} = \text{pindex} \)

#### Nontraded sectors and sectors with fixed export prices:

1. \( \text{imn PM(imn)} = 0 \)  
2. \( \text{imn M(imn)} = 0 \)  
3. \( \text{ien PE(ien)} = 0 \)  
4. \( \text{ien E(ien)} = 0 \)  
5. \( \text{iedn PWE(iedn)} = \text{pwe(iedn)} \)

would be to fix the value of \( \text{EXR} \) (relative to the numeraire price index). The balance of trade would then be determined endogenously and one of the financing items (FSAV, REMIT, or FBOR) would have to be made into an endogenous variable.

The final macro closure condition (equation 46) requires that aggregate savings equals aggregate investment. Government revenue is determined by the various fixed tax parameters, and government saving (GOVSAV), as mentioned earlier, is determined residually in equation 44. Private savings are determined by various fixed institutional and household savings rates. Foreign saving is also fixed exogenously. The net effect is to specify a savings-driven model in which aggregate investment is determined by aggregate savings. This specification is called "neoclassical closure" in the CGE literature. Most of the U.S. applications of CGE models use some form of neoclassical closure. There are many alternative ways to achieve savings-investment equilibrium in the model, reflecting different theoretical perspectives on how the macro economy operates.\(^{20}\)

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\(^{20}\)There is extensive literature on alternative macro closures of CGE models. See Robinson (1989a,b), Rattso (1982), and Dewatripont and Michel (1987). The seminal article is Sen (1963).
In a standard general equilibrium model, the system can only determine relative prices. The choice of numeraire (equation 53) should thus have no effect on the solution value of any real variables. As written, however, the real side of the CGE model is not homogeneous of degree zero in prices. That is, for example, doubling the numeraire price index (PINDEX) would not lead to a new solution with all real variables unchanged and all prices (including the exchange rate) doubled. The problem is that certain variables have been fixed exogenously in nominal terms: government transfers to enterprises and households, GENT and HHT. Unless these items are changed proportionately with any change in the numeraire price index, the real value of the transfers will change. Note that the foreign saving items (FSAV, REMIT, and FBOR) are not a problem, since they are fixed in foreign currency. Their value in domestic currency will change with the exchange rate, which will vary with the numeraire price index.

Counting Equations and Variables

The CGE model can be seen as a set of simultaneous nonlinear equations. Most such models are well-behaved neoclassical general equilibrium models that satisfy the conditions for existence proofs and will thus have at least one solution. In theory, models with many consumers (a typical formulation in applied CGE models) may have multiple equilibrium solutions. In practice, modelers have not found multiple equilibria, so the possibility is evidently more a problem for theorists than practitioners. See Kehoe (1985) and Mas Colell (1985) for discussions of the theoretical issues.

While generally neither necessary nor sufficient to ensure the existence of a solution, it is nonetheless reassuring to check that the number of endogenous variables equals the number of independent equations. Careful counting, set out below, indicates that the number of equations, including those that fix some variables exogenously, is one more than the number of endogenous variables.21 The CGE model, however, satisfies Walras' Law and the equations defining the equilibrium conditions are not all independent. Any one of them can be dropped, thus equating the number of variables and equations. In the GAMS model, we drop equation 46, the savings-investment equilibrium condition. A test of the model solution is to compute aggregate savings and investment and check to see that they are equal, even though the equation is not explicitly included in the system that is solved.

Table 7 provides a count of equations and variables for the 10-sector U.S. model listed in Appendix 2. The number of variables and equations for each block is counted using the set indexes; i, f, ins, hh. For this model, the index values are: i = 10, f = 3,

---

21Equations 54 to 58 are included to account for sectors in which there are no exports or imports, or for which there are no export demand functions.
### Table 7--Count of equations and variables

**Variables:**

<table>
<thead>
<tr>
<th>Block</th>
<th>Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price block:</td>
<td>((8\cdot i) + 2) = 82</td>
</tr>
<tr>
<td>Quantity block:</td>
<td>((6\cdot i) + (f\cdot i) + 3) = 93</td>
</tr>
<tr>
<td>Income block:</td>
<td>((5\cdot i) + f + \text{ins} + hh + 22) = 81</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>((19\cdot i) + (f\cdot i) + f + \text{ins} + hh + 27) = 256</td>
</tr>
</tbody>
</table>

**Equations:**

<table>
<thead>
<tr>
<th>Block</th>
<th>Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price block:</td>
<td>(im + ie + (4\cdot i) + 1) = 60</td>
</tr>
<tr>
<td>Quantity block:</td>
<td>((2\cdot i) + (f\cdot i) + (2\cdot ie) + ien) + ied + ((2\cdot im) + imn) = 92</td>
</tr>
<tr>
<td>Income block:</td>
<td>(f + hh + 14) = 20</td>
</tr>
<tr>
<td>Expenditure block:</td>
<td>((5\cdot i) + 14) = 53</td>
</tr>
<tr>
<td>Market clearing block:</td>
<td>(i + f + 3) = 16</td>
</tr>
<tr>
<td>Macro closure:</td>
<td>(7) = 7</td>
</tr>
<tr>
<td>Nontraded sectors:</td>
<td>((2\cdot imn) + (2\cdot ien) + iedn) = 9</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>((12\cdot i) + (f\cdot i) + (3\cdot im) + (3\cdot ie) + ied + (3\cdot imn) + (3\cdot ien) + iedn + (2\cdot f) + hh + 28) = 257</td>
</tr>
</tbody>
</table>

\(\text{ins} = 3, \text{and hh} = 3.\) The subsets of "i" for the model are: \(im = 9, ie = 10, ied = 3, imn = 1, ien = 0,\) and \(iedn = 7.\) There are 256 variables and 257 equations, one more equation than endogenous variables. However, as discussed above, the equations are not all independent and one of the equilibrium conditions can be dropped. Typically, the savings-investment or balance-of-trade equilibrium condition, equation 46 or 45, is dropped. In our model, we drop the savings-investment equation.

**Calibration of Model Parameters**

In this section, we describe how base year data are used to calibrate model parameters. We calibrate parameters from a 1982 Social Accounting Matrix (SAM) data base plus additional estimated parameters such as values of various elasticities. The

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22Adelman and Robinson (1978) and Dervis, de Melo, and Robinson (1982) typically dropped the excess-demand equation for the largest sector. Condon, Dahl, and Devarajan (1987) dropped the balance-of-trade equation. A symmetric approach is to define an additional endogenous variable equal to the difference between aggregate savings and investment and leave in the redundant equation. The additional variable must equal zero at the equilibrium solution.
base year model solution, given the calibrated parameters, should reproduce the base year SAM. Making sure the solution SAM is consistent with the input data SAM is a useful consistency check of the model equations, SAM data base, and calibrated parameters.

The data on the U.S. economy are organized into a SAM. Construction of the SAM is a major task in itself. The development of the 1982 SAM for the United States is discussed in Hanson and Robinson (1989). In figure 2, we present an aggregated 1982 SAM which is consistent with the U.S. National Income and Product Accounts (NIPA).

The disaggregated SAM combines the input-output tables with the NIPA. The U.S. input-output tables are produced every 5 years. The last published table is for 1977. See U.S. Department of Commerce, Bureau of Economic Analysis (1984). The input-output table was updated to 1982 under a contract with the U.S. Forest Service. With some further adjustments, this updated table provides the core data set for our model. In addition to the data in the NIPA and input-output tables, the data base for a CGE model includes quantity measures for factors of production, a capital composition matrix, and various elasticities.

Common practice in calibrating CGE models is to assume that the base year of the model is also the base year for price indices. Units are defined so that all prices equal one, and the sectoral flows in the SAM measure both real and nominal magnitudes. The initial goods market equilibrium between supply and demand is thus obtained at prices equal to one. Such choice of units simplifies the calibration procedure, although it is not required.

In calibration, the model equations are solved in reverse. Given base-year values for the variables, the parameters are derived from the equations. Calibration is a mathematical, not a statistical, procedure. We describe the calibration procedure for some of the parameters, following the equation blocks above.

Production and Trade Aggregation Functions

For the quantity equation block, equations 8-17, we need to calibrate the parameters of the Cobb-Douglas production function, the CES aggregation function for imports and domestic goods, and

---

23 The data organization and reconciliation were facilitated by using a Fortran program called the "SAM Generator." The structure of the program is described in an appendix to Dervis, de Melo, and Robinson (1982).

24 The work was done by a consulting firm called Engineering Economics Associates of Berkeley, California. When the official U.S. input-output tables for 1982 become available, we will update the 1982 SAM data base.

25 In recent work with the USDA/ERS CGE model, we have rebased the model on a 1986 SAM with real magnitudes defined in terms of 1982 prices.
Figure 2--A SAM for the United States in 1982

<table>
<thead>
<tr>
<th></th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
<th>Column 6</th>
<th>Column 7</th>
<th>Column 8</th>
<th>Column 9</th>
<th>Row Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Billions of dollars</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commodity</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>5,948.6</td>
</tr>
<tr>
<td>Activity</td>
<td>5,604.4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,966.3</td>
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<tr>
<td>Value added</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,907.0</td>
</tr>
<tr>
<td>Capital</td>
<td>1,000.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Institutional actors</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Enterprise</td>
<td>1,000.2</td>
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<td></td>
<td></td>
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<td>1,047.8</td>
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<tr>
<td>Household</td>
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<td>581.6</td>
<td>396.2</td>
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<td>Government</td>
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<td>63.1</td>
<td>409.3</td>
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<td></td>
<td>403.1</td>
<td>154.0</td>
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<td></td>
<td></td>
<td>447.3</td>
</tr>
<tr>
<td>World</td>
<td>335.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>335.6</td>
</tr>
<tr>
<td>Column totals</td>
<td>5,948.6</td>
<td>5,966.3</td>
<td>1,907.0</td>
<td>1,000.2</td>
<td>1,047.8</td>
<td>2,614.0</td>
<td>974.6</td>
<td>447.3</td>
<td>335.6</td>
<td></td>
</tr>
</tbody>
</table>
the CET transformation function for exports and domestic sales. In each, we choose elasticity values from econometric estimates available in the literature. Given these elasticities, the shift and share parameters can be calibrated from the base year data.

The Cobb–Douglas production function, equation 8, has four parameters: the three factor-share parameters and the shift parameter. The SAM data include production, \( XD(i) \), factor demand, \( FDSC(i,f) \), and factor income, \( FCTRY(i,f) \), all by sector. From factor demand by sector and factor income by sector the average factor price \( WF(f) \) and the factor price sectoral proportionality constants, \( wfdist(i,f) \), are calculated. In the next part of this section, we go into more detail on the factor price calculations.

The value-added price, \( PVA(i) \), also goes into the calculation of the production function parameters. This price depends on the producer price, the cost of intermediate goods, and the indirect business tax. Note that production and factor demand account for market distortions, because the distortions are captured in the \( wfdist \) parameters and in the value-added prices:

\[
PVA(i) = PX(i)(1 - itax(i)) - \sum(j, io(j,i)*P(j))
\]

which include ad valorem distorting taxes, \( itax(i) \). Any other ad valorem tax or subsidy instruments can either be added to the model in the value-added price equation or included in the \( itax \) parameters.

The first order conditions for profit maximization, equation 9, define the factor demand equations. From equation 9, solve for the share parameters, \( \alpha(i,f) \):

\[
\alpha(i,f) = wfdist(i,f)*WF(f)*FDSC(i,f)/(PVA(i)*XD(i))
\]

Given that the data from the SAM add up, total factor payments must equal total value added in each sector. The effect is to assume constant returns to scale in production, so that the \( \sum(f, \alpha(i,f)) \) will equal one in all sectors.

Once the factor shares are determined, the shift parameter of the Cobb–Douglas production function remains to be calibrated. Given the data on total output \( XD(i) \), factor employment \( FDSC(i,f) \), and the calibrated \( \alpha(i,f) \), the \( ad(i) \) parameters are given by (from equation 8):

\[
ad(i) = XD(i)/PROD(f, FDSC(i,f)**\alpha(i,f))
\]

Calibration of the CES and CET trade aggregation functions is very similar to the treatment of the production functions. The CES and CET functions are characterized by a non-unitary elasticity of substitution or transformation, share parameters (which sum to one), and a shift term. The various model equations do not suffice to identify all these: one parameter must be determined outside the model. Standard practice is to
use outside econometric estimates of the elasticity of substitution or transformation.\textsuperscript{26}

For the CES function, the elasticity of substitution measures the degree to which imported and domestic versions of the "same" good can be substituted for each other. In the model, the \( \text{rhoc}(i) \) parameter equals \((1/\text{elasticity} - 1)\). An analogous relationship holds for the \( \text{rhot}(i) \) parameter in the CET function.\textsuperscript{27}

Given these elasticities, the import demand and export supply equations can be used to solve for the share parameters in the CES and CET function. From equation 17, the import demand equation, the delta parameters can be computed in two steps (with \( \delta \) as an intermediate calculation):

\[
\begin{align*}
\delta 1(i) & = \frac{\text{PM}(i)/\text{PD}(i)}{\text{M}(i)/\text{XXD}(i)}(1 + \text{rhoc}(i)) \\
\delta(i) & = \frac{\delta 1(i)}{1 + \delta 1(i)}
\end{align*}
\]

Finally, the shift parameters are calculated from equation 15:

\[
\begin{align*}
\text{ac}(i) & = \frac{\text{X}(i)}{\delta(i)\text{M}(i)^{-\text{rhoc}(i)}} \\
& + \frac{1 - \delta(i)\text{XXD}(i)^{-\text{rhoc}(i)}}{\delta(i)}
\end{align*}
\]

The computation for the export supply function is similar.

Factor Price Sectoral Proportionality Constants

The parameters \( \text{wfdist}(i,f) \) relate sector-specific factor returns to the economywide average factor return, \( \text{WF}(f) \). The SAM includes data on factor payments by factor and sector. Coupled with data on the number of units of factors (workers, capital stock, and acres of land), both the sector-specific and economywide average factor returns can be calculated. For example, the sector-specific wage equals a sector's "wage bill" divided by the number of workers in the sector. The average wage is the economywide wage bill divided by the total number employed. \( \text{wfdist}(i," labor") \) for a sector is the ratio of the sector-specific to the average wage.

Gross capital returns by sector can be determined residually given data on value added, wages, and land rental. Given estimates of sectoral capital stocks, sectoral capital rental rates and the \( \text{wfdist}(i," capital") \) parameters can be computed in the same manner as the parameters for labor.\textsuperscript{28} An alternative approach used by Ballard, Fullerton, Shoven, and Whalley (1985) is to start with calculated \( \text{wfdist} \) parameters. They assume that the only reason capital rentals differ across sectors is

\textsuperscript{26}For the United States, substitution elasticities for imports have been estimated by Shiells, Stern, and Deardorff (1986), and more recently, by Reinert and Roland-Holst (1990).

\textsuperscript{27}In the GAMS program, the parameters are read in as elasticities and the \( \text{rhoc} \) and \( \text{rhot} \) parameters are computed.

\textsuperscript{28}We use capital-stock data from the U.S. Department of Commerce, Bureau of Economic Analysis (1987).

24
variation in tax rates. Given data on sectoral taxes, they estimate the \( w_{fdist} \) parameter for capital in each sector. Assuming that after-tax rental rates must be equal across sectors, they then use an estimate of the economywide rental rate to compute sectoral capital stocks.

The \( w_{fdist}(i,f) \) parameters reflect: (1) distortions in the factor markets such as impediments to factor mobility among sectors or differential tax rates, and/or (2) aggregation errors in the definition of factors. Examples of the second effect might be variations in capital vintages across sectors that are not captured in capital stock data or variations in the occupation, skill, or education composition of the labor force across sectors. The general equilibrium model assumes that the return to a given factor would be equal across sectors if the factors were indeed homogeneous and there were no rigidities or distortions.

The fact that there are rigidities and distortions is reflected in that the measured \( w_{fdist}(i,f) \) parameters differ from one. By assuming these parameters to be constant across experiments, the modeler assumes that the structural characteristics responsible for the differentials are invariant to the question at hand. That is, all policy experiments must be seen as comparing second-best situations, given existing factor-market distortions. Indeed, the existence of such distortions is a strong argument for using CGE models, since welfare comparisons in second-best situations are usually theoretically ambiguous, with results depending on parameter values. Of course, it is possible to do experiments in which the \( w_{fdist} \) parameters are changed, which is the approach taken in much of the public finance literature using CGE models.29

**Tax and Saving Rates in the Income Equations**

The parameters in the income equations include the institutional tax and saving rates as well as household tax and saving rates. The SAM data provide the values of total institutional and household income and the amounts saved and paid in taxes. The average tax and saving rates are simply calculated as the ratios of taxes or savings to the income base.

The institutional structure of the model depends on the household aggregation. For the types of households in the basic model, we distinguish institutions by their functional source of income. Institutional income is factor income net of institutional taxes and savings, and includes government transfers. The net income of the labor institution is labor income net of social security taxes.

The net income of the enterprise institution is the capital income of producers, net of the profit tax on enterprise income, retained earnings which goes to the capital account, and

29 For a survey of tax models, see Shoven and Whalley (1984).
depreciation which also goes to the capital account. Note that depreciation equals the depreciation rate depr(i) times the value of productive capital valued at replacement cost, an economic rather than a tax definition. The enterprise institution also receives business transfer payments from the government. The property institution receives the factor income for land.

Net institutional income is apportioned to households using fixed share parameters, sintyh(hh,ins), which represent shares of each type of institutional income received by the different household categories. For these parameters, the sum over households equals one for all institutions. The USDA/ERS CGE model can distinguish households in either of two ways: (1) according to income class (such as lower 40th percentile, mid-40th percentile, and upper 20th percentile); or (2) according to function or income source, such as workers, capitalists (or rentiers), and transfer recipients. The model presented in Appendix 2 follows the functional household definition. For example, if only worker households earn the economy's labor income, the share to worker households is one, that is sintyh(worker,labor) = 1; while for nonworker households it is zero. All distributed profits and property income go to rentier households.

Household income is taxed, saved, or spent on consumer goods and services. The income received by households includes remittances from abroad, transfers from the government, and factor income. Household income tax payments are computed as an average tax rate times gross income, which includes transfer income and remittances from abroad (or net of remittances sent out of the country). The average tax rate, htax(hh), for each household type is calibrated from the income flows and taxes paid in the base year. Household average savings rates, mps(hh), are determined as the ratio of household savings to income net of taxes. Household remittances from abroad, REMIT, are exogenous variables denominated in foreign currency. Consequently, they are multiplied by the exchange rate to determine domestic income flows. Household remittance shares, rhsh(hh), are computed from base-year data.

**Sectoral Composition of Expenditures**

There are a number of parameters that determine the sectoral composition of various categories of demand. These categories include: (1) demand for intermediate inputs, io(i,j); (2) composition of capital goods, imat(i,j); (3) household average expenditure shares, cles(i,hh); (4) investment allocation by sector of destination, kish(i); and (5) government demand shares, gles(i). All these parameters are computed from base-year data.

Intermediate goods are demanded in fixed proportions, using input-output coefficients io(i,j) defined in real terms (that is,}

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units of input per unit output). Note that intermediate demand is for the composite good. The elements of the capital composition matrix, \text{imat}(i,j), are also defined in real terms as units of composite good \(i\) required per unit of capital in sector \(j\). While these coefficients are fixed, the import shares are not because they are a function of relative prices (given the sectoral import aggregation functions).

The demand by household \(hh\) for good \(i\) depends on the \text{cles}(i, hh) parameters, which represent expenditure shares—the fraction of household \(hh\)'s total nominal expenditure that is spent on good \(i\). The different expenditure shares across household type are estimated from data on expenditure shares by income class. The government sectoral expenditure shares, \text{gles}(i), are defined in real terms since total government expenditure (GDTOT) is defined as a real magnitude. These shares are taken from the input-output table. Finally, the allocation of total nominal investment by sector of destination, the \text{kish}(i) parameters, are based on data from U.S. Department of Commerce, Bureau of Economic Analysis (1987).

**Implementing the CGE Model in GAMS**

Table 8 presents an outline of a CGE model programmed in GAMS. For those familiar with GAMS, the outline uses terms describing a typical GAMS program. See the GAMS manual by Brooke, Kendrick, and Meeraus (1988). The model listing in Appendix 2 follows this outline.

A GAMS program typically starts with statements that define "sets" used in the model. In the CGE model, these sets define the various indices for subscripted variables and parameters. We distinguish sets for production sectors, factors of production, institutions, and households.

Second, we declare and define the various parameters in the model. In the CGE model, there are three kinds of parameters. First, the entire base-year SAM is read in. Second, parameters that are estimated outside the model, such as various elasticities, are read in. Third, based on the read-in data and parameters, the remaining parameters are computed, completing the calibration process.

Third, the endogenous variables in the model are declared and defined. The solution procedure also requires that all endogenous variables be given an initial value to start the algorithm. In programming models, if initial values are not specified, most algorithms try a guess of zero. For a CGE model, where the solution is expected to yield strictly positive prices and quantities, such a guess would often lead to singularities.

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31 The capital composition matrix is derived from the capital flows table published by the U.S. Department of Commerce, Bureau of Economic Analysis (1985).
or, at best, nasty scaling problems. It is important to provide guesses as close as possible to the expected solution. We use the base-year SAM to initialize all endogenous variables.

Fourth, the base-year SAM from calibrated parameters is displayed. This SAM should replicate the initial data before the model is solved, and provides a check on the data input, parameter calibration, and initialization of endogenous variables. If the calibration procedure is done correctly, the solution of the CGE model in the base year should replicate the initial SAM (within acceptable rounding error). Printing the pre-solution and post-solution SAM's facilitates debugging the calibration process.

Fifth, the equations of the model are declared and defined. The GAMS program follows closely the presentation of equations above. Then, sixth, the model is defined and solved. The equations that are to be included in the CGE model are listed. Next, there is a SOLVE statement that calls a solution algorithm, such as NLP for nonlinear programming, to solve the model.

Finally, after the SOLVE statement is executed, GAMS has solution values for all endogenous variables. It remains only to print them. This is done in part seven. GAMS has standard defaults.
for printing solution reports. We turn off the default solution printing and generate our own output tables.

After a base-year or "benchmark" solution is created, the CGE model will typically be used to run counterfactual, comparative static, experiments. A parameter or exogenous variable is changed and the model is solved again. Given the structure of the GAMS program, it is important to make such changes after the initialization of parameters, but before the model SOLVE statement. A common error is to change some input data in the parameter assignment part of the program. What happens in this case is that all the calibrated parameters are changed to be consistent with the changed input data, completely changing the model. The result is not a comparative statics experiment, but a comparison of two different models that may, depending on the nature of the changed parameters, have the same SAM. We have found it convenient to do experiments using the SAVE and RESTART commands in GAMS. In this procedure, the base solution is saved and a new experiment file is created that includes the model changes, solve statement, and display statements for tables of results. Experiment results are generated by using the RESTART option when running the experiment GAMS program.

Applications, Variations, and Extensions

In this section, we discuss how the USDA/ERS CGE model has been used. The model is very close to the Walrasian, neoclassical paradigm. In most applications, it is necessary to make changes in the institutional and behavioral assumptions in order to have the model better reflect the workings of an actual economy. We will discuss some changes that have been used in the USDA/ERS model to analyze policy issues relating to agriculture and international trade.32

Comparative Statics and Dynamics

The CGE model described here represents a single period equilibrium. None of the arguments in the various equations involve lagged variables or expected future variables, so the model is really timeless. It determines a flow equilibrium based on signals for the current period only. A given benchmark solution does, however, reflect initial conditions and past circumstances captured in the base-year data set.

32We make no attempt to provide a general survey of applications of CGE models. See Robinson (1989b) for a survey of applications to developing countries, Robinson (1990) and Hertel (1990) for surveys of agriculture-focused models, de Melo (1988) for a survey of recent trade-focused CGE models, Shoven and Whalley (1984) for an earlier review of models on taxation and trade, and Powell and Lawson (1986) for a review of policy modeling with the Australian ORANI model.
The most common use of CGE models is to do comparative statics experiments. The interpretation of the results involves a very simple notion of time: "long enough" for all specified equilibrium conditions to be satisfied. Whether that period is short, medium, or long run depends on assumptions about elasticities and factor mobility in the model. For example, the basic model assumes all factors are mobile, a longrun assumption.

Since the first applications of CGE models to developing countries, the models have been made dynamic by solving for a sequence of time-recursive solutions. Time-dependent variables (such as the aggregate capital stock, labor force, and total factor productivity) are "updated" between periods. These dated variables are assumed exogenous within periods. Time-recursive dynamic paths are generated as a sequence of static CGE models linked by an intertemporal model that updates dated variables.33

We have used this approach with the USDA/ERS model. Adelman and Robinson (1988) analyzed the 1981 to 1985 period. Robinson, Kilkenny, and Adelman (1989) used forward projections from 1986 to 1991. Hanson, Robinson, and Tokarick (1990) project from 1988 to 1991 and 1995. In the last two applications, the CGE model is loosely linked to econometric macroeconomic projection models which provide estimates of real GNP growth, foreign prices, the government deficit, the balance of trade, and the aggregate price level. Robinson, Kilkenny, and Adelman used the "Trend Growth Model" (TGM), which is described in Monaco (1987). Hanson, Robinson, and Tokarick use results from a world econometric model developed in the ERS by Malley (1990). The macro models provide a logical framework for modeling intertemporal linkages and nicely complement the within-period CGE model.34

Adelman and Robinson (1978) describe this approach to dynamics as "lurching equilibrium" and it captures many elements of "adaptive" dynamic models and "temporary equilibrium" macro models.35 This approach to dynamics has been criticized by Bell and Srinivasan (1984) who argue that the models are not forward looking and hence are not "truly" dynamic. There are a few examples of forward-looking dynamic CGE models, ranging from two-period to longrun multiperiod models, but they are quite stylized.36 Bell and Srinivasan also note that dynamic equilibrium models can only be used to generate steady-state solutions, and that such solutions are usually not very

33 This is the technique first used by Adelman and Robinson (1978). It has later been used in applications to developing countries. See Dervis, de Melo, and Robinson (1982).
34 This approach to linking CGE and macro models is described in Robinson and Tyson (1984) and has also been used in Australia. See Cooper, McLaren, and Powell (1985).
35 See Day and Cigno (1978) for examples of adaptive dynamic models.
realistic. Since applied models build on existing theory, not advance it, future advances in applied dynamic models will require further theoretical developments. Parsell, Powell, and Wilcoxen (1989) discuss some recent developments in reconciling applied general equilibrium models with dynamic macroeconomics.

Factor Markets

In the basic model, all primary factors of production are perfectly mobile. Given the fixed total supplies of primary factors, economywide average factor prices adjust to maintain full employment equilibrium. An alternative widely used in models of developing countries is to assume the sectoral employment of a primary factor such as capital is fixed. The underlying story is that the model incorporates a shortrun adjustment period in which capital is assumed immobile.

Fixing factor employment by sector amounts to adding equations to the system, so an equal number of endogenous equilibrating variables must be included. With sectoral capital stocks fixed, one must assume that sectoral rental rates will vary. This specification is easily accommodated in the CGE model by redefining the wfdist(i,f) parameters as variables and fixing the average factor price variable to one. Kilkenny and Robinson (1988, 1990) use this specification to explore the effect of policy changes under different assumptions about factor mobility.

Another common factor market assumption is to assume that the wage is not flexible. With a fixed wage, the labor market is assumed to be rationed. The standard assumption is that producers hire as much labor as they wish at the fixed wage and that suppliers are rationed; that is, there is involuntary unemployment. This specification is easily accommodated in the CGE model by specifying the wage as an exogenous variable and aggregate labor supply as endogenous. This option is noted with comments in the GAMS listing in Appendix 2.

Modeling Agricultural Programs

The USDA/ERS model was developed to analyze the impact on the economy of proposed changes in agricultural policies. To date, most of the applications have concerned trade liberalization and have worked with a 10-sector version of the model. The standard approach to modeling agricultural programs has been to measure their total cost and use an equivalent fixed ad valorem subsidy in the model. In the CGE model, this approach would be implemented by creating a subsidy parameter that would enter the model as a negative indirect tax. Everywhere the parameter itax(i) appears, there would be an additional subsidy parameter.

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38 These subsidy rates, called producer subsidy equivalents or PSE's, have been computed for a number of countries. The data are reported in U.S. Department of Agriculture, Economic Research Service (1988).
Kilkenny and Robinson (1988, 1990) argue that using ad valorem equivalents is not an adequate approach to modeling the complex mix of agricultural policies in the United States. They have extended the basic CGE model to include an explicit modeling of the different government programs affecting U.S. agriculture, including import rationing, export subsidies, deficiency payments, and government stocking. Their empirical results indicate that explicit modeling of the programs is especially important when estimating changes in the cost of government programs under different macro and policy scenarios, as well as for welfare analysis and analysis of the effect on linked sectors of policy changes.

The explicit modeling of agricultural programs is, of necessity, fairly stylized in the context of a 10-sector model with only 3 agricultural sectors. The basic model has recently been expanded to include 30 sectors in order to provide a better framework for such analysis. This expanded model should provide a richer framework for analyzing trade liberalization scenarios and proposed policy changes being discussed in the context of the 1990 farm bill.

39 Kilkenny (1990) describes how agricultural programs are modeled in the new 30-sector model.
References


Appendix 1: Model Summary

This appendix brings together all the model equations, including the list of variable and parameter definitions. Endogenous variables are in upper case and parameters are in lower case. To treat a variable as exogenous, we add the suffix "_.FX" (which means "fixed"). The suffix "_.L" means "level" and refers to the value of a variable. These suffixes follow the GAMS language. In GAMS, before the model is solved, the .L suffix denotes an initial guess. After solution, it denotes the solution value.

Indices are also in lower case, but are always given in parentheses. In some equations, the index is replaced by a specific entry, given in quotes. As noted earlier, the words SUM and PROD denote the summation and product operators over the index given after the left parenthesis (Σ and Π).

Indices

i, j Sectors
im Sectors with imports
imm Sectors without imports: im + imm = i
ie Sectors with exports
ien Sectors without exports: ie + ien = i
ied Sectors with world export demand functions
iedn Sectors with fixed world export prices: ied + iedn = ie
f Factors of production: "labor," "capital," and "land"
ins Institutions: "labr," labor; "ent," enterprises; "prop," proprietors
hh Household types

Parameters

ac(im) CES function shift parameter
ad(i) Production function shift parameter
alpha(i,f) Share parameter in production function
at(i,e) CET function shift parameter
cles(i,hh) Household expenditure shares
delta(im) CES function share parameter
depr(i) Depreciation rate
destr(i) Ratio of inventory investment to domestic output
econst(ied) Export demand function shift parameter
esr Enterprise saving rate
etrt Enterprise tax rate
fs(f) Aggregate factor supply
gamma(i,e) CET function share parameter
gles(i) Government expenditure shares
htax(hh) Household income tax rate
imat(i,j) Capital composition matrix
io(i,j) Input-output coefficients
itax(i) Indirect business tax rate
kish(i) Shares of investment by sector of destination
mps(hh) Household saving rate
pwm(im) World price of imports
pwse(ied) World price of export substitutes
rhoc(im) CES function exponent
rhot(ie) CET function exponent
rhsh(hh) Household remittance share
sintyh(hh,ins) Household distribution of institutional income
sstr Social security tax rate
tm(im) Tariff rate on imports
tmreal(im) Real tariff rate
t(e) Real export subsidy rate
tereal(ie) Real export subsidy rate
thsh(hh) Household share of government transfers
wfdist(i,f) Factor market distortion parameters

Variables

Prices Block

EXR Exchange rate
P(i) Price of composite good
PD(i) Domestic sales price
PE(i) Domestic price of exports
PINDEX GNP deflator
PK(i) Price of a unit of capital in each sector
PM(i) Domestic price of imports
PVA(i) Value added price
PWE(i) World price of exports
PX(i) Output price

Production Block

E(i) Exports
FDSC(i,f) Factor demand
INT(i) Intermediate input demand
M(i) Imports
WF(f) Average factor price
X(i) Composite goods supply
XD(i) Domestic output
XXD(i) Domestic sales

Income and Expenditure Blocks

CD(i) Final demand for private consumption
DEPRECIA Total depreciation charges
DK(i) Fixed Investment by sector of destination
DST(i) Inventory investment by sector
ENTSAV Enterprise savings
ENTTAX Enterprise tax revenue
FBOR Net foreign borrowing
FXDINV Fixed capital investment
FSAV Foreign savings
GD(i) Final demand for government consumption
GDTOT Aggregate real government consumption
GENT Transfer payments from government to enterprises
GNPVA Nominal GNP or value added in market prices
GOVSAV Government savings
GR Total government revenue
HHSAV Total household savings
HHT Government transfer payments to households
Final demand for investment goods
Total indirect tax revenue
Total investment
Total export subsidies
Net remittances from abroad
Real GNP
Total savings
Social security tax revenue
Tariff revenue
Household tax revenue
Factor income
Household income
Institutional income

Equations

Prices

(1) \( \text{im} \) \( \text{PM} \text{(im)} \) = \( \text{pwm}(\text{im})*(1 + \text{tm}(\text{im}))*\text{EXR} \)
(2) \( \text{ie} \) \( \text{PE} \text{(ie)} \) = \( \text{PWE}(\text{ie})*(1 + \text{te}(\text{ie}))*\text{EXR} \)
(3) \( \text{i} \) \( \text{P} \text{(i)} \) = \( (\text{PD}(\text{i})*\text{XXD}(\text{i}) + \text{PM}(\text{i})*\text{M}(\text{i}))/\text{X}(\text{i}) \)
(4) \( \text{i} \) \( \text{PX} \text{(i)} \) = \( (\text{PD}(\text{i})*\text{XXD}(\text{i}) + \text{PE}(\text{i})*\text{E}(\text{i}))/\text{XD}(\text{i}) \)
(5) \( \text{i} \) \( \text{PVA} \text{(i)} \) = \( \text{PX}(\text{i})*(1 - \text{itax}(\text{i})) - \text{SUM}(\text{j},\text{io}(\text{j},\text{i})*\text{P}(\text{j})) \)
(6) \( \text{i} \) \( \text{PK} \text{(i)} \) = \( \text{SUM}(\text{j}, \text{P}(\text{J})*\text{imat}(\text{j},\text{i})) \)
(7) \( \text{l} \) \( \text{PINDEX} \) = \( \text{GNPVA}/\text{RGNP} \)

Production

(8) \( \text{i} \) \( \text{XD} \text{(i)} \) = \( \text{ad}(\text{i})*\text{PROD}(\text{f}, \text{FDSC}(\text{i},\text{f})**\text{alpha}(\text{i},\text{f})) \)
(9) \( \text{i},\text{f} \) \( \text{WF} \text{(f)}*\text{wfdist}(\text{i},\text{f}) = \text{PVA}(\text{i})*\text{alpha}(\text{i},\text{f})*\text{XD}(\text{i})/\text{FDSC}(\text{i},\text{f}) \)
(10) \( \text{i} \) \( \text{INT} \text{(i)} \) = \( \text{SUM}(\text{j}, \text{io}(\text{i},\text{j})*\text{XD}(\text{j})) \)
(11) \( \text{ie} \) \( \text{XD} \text{(ie)} \) = \( \text{at}(\text{ie})*(\text{gamma}(\text{ie})*\text{E}(\text{ie})*\text{rhot}(\text{ie}) \)
+ \( (1 - \text{gamma}(\text{ie}))*\text{XXD}(\text{ie})*\text{rhot}(\text{ie}))*\text{ XD}(\text{ie})/(1/\text{rhot}(\text{ie})) \)
(12) \( \text{ien} \) \( \text{XD} \text{(ien)} \) = \( \text{XXD}(\text{ien}) \)
(13) \( \text{ie} \) \( \text{E} \text{(ie)} \) = \( \text{XXD}(\text{ie})*(\text{PE}(\text{ie})*\text{PD}(\text{ie})*(1 - \text{gamma}(\text{ie}))/ \)
\( \text{gamma}(\text{ie}))*\text{XXD}(\text{ie})/(1/\text{rhot}(\text{ie})-1) \)
(14) \( \text{ied} \) \( \text{E} \text{(ied)} \) = \( \text{econst}(\text{ied})*((\text{PWE}(\text{ied})*\text{pwe}(\text{ied}))*(-\text{rho}(\text{ied}))) \)
(15) \( \text{im} \) \( \text{X} \text{(im)} \) = \( \text{ac}(\text{im})*\text{(delta}(\text{im})*\text{M}(\text{im})*(-\text{rhoc}(\text{im}))+ \)
\( (1-\text{delta}(\text{im}))*\text{XXD}(\text{im})*(-\text{rho}(\text{im})))**(-1/\text{rhoc}(\text{im})) \)
(16) \( \text{imn} \) \( \text{X} \text{(imn)} \) = \( \text{XXD}(\text{imn}) \)
(17) \( \text{im} \) \( \text{M} \text{(im)} \) = \( \text{XXD}(\text{im})*((\text{PD}(\text{im})*\text{PM}(\text{im}))*\text{(delta}(\text{im}))/ \)
\( (1-\text{delta}(\text{im})))**((1/(1 + \text{rhoc}(\text{im})))) \)

Income Generation

(18) \( \text{f} \) \( \text{YFCTR} \text{(f)} \) = \( \text{SUM}(\text{i}, \text{WF}(\text{f})*\text{wfdist}(\text{i},\text{f})*\text{FDSC}(\text{i},\text{f})) \)
(19) \( \text{l} \) \( \text{YINST} \text{("labr")} \) = \( \text{YFCTR}(\"labor\") - \text{SSTAX} \)
(20) \( \text{l} \) \( \text{YINST} \text{("prop")} \) = \( \text{YFCTR}(\"land\") \)
(21) \( \text{l} \) \( \text{YINST} \text{("ent")} \) = \( \text{YFCTR}(\"capital\") + \text{GENT} - \text{ENTSAV} - \text{ENTTAX} - \text{DEPRECIA} \)
(22) \( \text{hh} \) \( \text{YH} \text{(hh)} \) = \( \text{SUM}(\text{ins}, \text{sintyh}(\text{hh},\text{ins})*\text{YINST}(\text{ins})) \)
+ \( \text{rhsh}(\text{hh})*\text{REMIT}*\text{EXR} + \text{thsh}(\text{hh})*\text{HHT} \)
(23) \( \text{l} \) \( \text{TARIFF} \) = \( \text{SUM}(\text{i}, \text{tm}(\text{i})*\text{pwm}(\text{i})*\text{M}(\text{i}))*\text{EXR} \)
(24) \( \text{l} \) \( \text{INDTAX} \) = \( \text{SUM}(\text{i}, \text{itax}(\text{i})*\text{PX}(\text{i})*\text{XD}(\text{i})) \)
(25) \( \text{l} \) \( \text{NETSUB} \) = \( \text{SUM}(\text{ie}, \text{te}(\text{ie})*\text{PWE}(\text{ie})*\text{E}(\text{ie}))*\text{EXR} \)
(26) \( \text{l} \) \( \text{SSTAX} \) = \( \text{sstr}*\text{YFCTR}(\"labor\") \)

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(27) 1 \text{ENTTAX} = \text{etr}(\text{YFCTR("capital")}) - \text{DEPRECIA} + \text{GENT} \\
(28) 1 \text{TOTHTAX} = \text{SUM}(\text{hh}, \text{htax}(\text{hh})*\text{Y}(\text{hh})) \\
(29) 1 \text{DEPRECIA} = \text{SUM}(\text{i}, \text{depr}(\text{i})*\text{PK}(\text{i})*\text{FDSC}(\text{i}, \text{"capital"})) \\
(30) 1 \text{ENTSAV} = \text{ESR}((\text{YFCTR("capital")}) + \text{GENT} - \text{ENTTAX} - \text{DEPRECIA}) \\
(31) 1 \text{HHSAV} = \text{SUM}(\text{hh}, \text{mps}(\text{hh})*\text{Y}(\text{hh})*(1 - \text{htax}(\text{hh}))) \\
(32) 1 \text{GR} = \text{TARIFF} - \text{NETSUB} + \text{INDTAX} + \text{TOTHTAX} + \text{SSTAX} \\
+ \text{ENTTAX} + \text{FBOR*EXR} \\
(33) 1 \text{SAVINGS} = \text{HHSAV} + \text{GOVSAV} + \text{DEPRECIA} + \text{FSAV*EXR} + \text{ENTSAV} \\

\text{Expenditure} \\
(34) 1 \text{P}(\text{i})*\text{CD}(\text{i}) = \text{SUM}(\text{hh}, \text{cles}(\text{i},\text{hh})*(1 - \text{mps}(\text{hh}))*\text{Y}(\text{hh}) \\
*(1 - \text{htax}(\text{hh}))) \\
(35) 1 \text{GD}(\text{i}) = \text{gles}(\text{i})*\text{GDTOT} \\
(36) 1 \text{DST}(\text{i}) = \text{dstr}(\text{i})*\text{XD}(\text{i}) \\
(37) 1 \text{FXDINV} = \text{INVEST} - \text{SUM}(\text{i}, \text{DST}(\text{i})*\text{P}(\text{i})) \\
(38) 1 \text{PK}(\text{i})*\text{DK}(\text{i}) = \text{kish}(\text{i})*\text{FXDINV} \\
(39) 1 \text{ID}(\text{i}) = \text{SUM}(\text{j}, \text{imat}(\text{i},\text{j})*\text{DK}(\text{j})) \\
(40) 1 \text{GNPVA} = \text{SUM}(\text{i}, \text{PVA}(\text{i})*\text{XD}(\text{i})) + \text{INDTAX} + \text{TARIFF} - \text{NETSUB} \\
(41) 1 \text{RGNP} = \text{SUM}(\text{i}, \text{CD}(\text{i}) + \text{DST}(\text{i}) + \text{ID}(\text{i}) + \text{GD}(\text{i})) \\
+ \text{SUM}(\text{ie}, (1 - \text{tereal}(\text{ie}))*\text{E}(\text{ie})) \\
- \text{SUM}(\text{im}, (1 - \text{tmreal}(\text{im}))*\text{M}(\text{im})) \\

\text{Equilibrium Conditions} \\
(42) 1 \text{X}(\text{i}) = \text{INT}(\text{i}) + \text{CD}(\text{i}) + \text{GD}(\text{i}) + \text{ID}(\text{i}) + \text{DST}(\text{i}) \\
(43) 1 \text{SUM}(\text{i}, \text{FDSC}(\text{i}, \text{f})) = \text{fs}(\text{f}) \\
(44) 1 \text{GR} = \text{SUM}(\text{i}, \text{P}(\text{i})*\text{CD}(\text{i})) + \text{GOVSAV} + \text{GENT} + \text{HHT} \\
(45) 1 \text{SUM}(\text{im}, \text{PWM}(\text{im})*\text{M}(\text{im})) = \text{SUM}(\text{ie}, \text{PWE}(\text{ie})*\text{E}(\text{ie})) \\
+ \text{FSAV} + \text{REMIT} + \text{FBOR} \\
(46) 1 \text{SAVINGS} = \text{INVEST} \\

\text{Macro Closure: Balance of Trade} \\
(47) 1 \text{FSAV.FX} = \text{fsav.1} \\
(48) 1 \text{REMIT.FX} = \text{remit.1} \\
(49) 1 \text{FBOR.FX} = \text{fbor.1} \\

\text{Macro Closure: Government Balance} \\
(50) 1 \text{GDTOT.FX} = \text{gdtot.1} \\
(51) 1 \text{GENT.FX} = \text{gent.1} \\
(52) 1 \text{HHT.FX} = \text{hht.1} \\

\text{Numeraire Price Index} \\
(53) 1 \text{PINDEX.FX} = \text{pindex.1} \\

\text{Nontraded Sectors and Fixed Export Prices} \\
(54) \text{imn} \text{ PM.FX}(\text{imn}) = 0 \\
(55) \text{imn} \text{ M.FX}(\text{imn}) = 0 \\
(56) \text{ien} \text{ PE.FX}(\text{ien}) = 0 \\
(57) \text{ien} \text{ E.FX}(\text{ien}) = 0 \\
(58) \text{iedn} \text{ PWE.FX}(\text{iedn}) = \text{pwe.1(iedn)}
Appendix 2: GAMS Listing of U.S. CGE Model

This appendix provides a listing of the output from a GAMS execution of the U.S. model for 1982. Some output tables have been omitted to save space.

In solving CGE models, the GAMS program uses software designed to solve nonlinear programming problems. The solver most commonly used is the MINOS program developed at Stanford University, described in Appendix D of Brooke, Kendrick, and Meeraus (1988). The CGE model is treated by MINOS as a special programming problem that happens to have a unique feasible basis. Since there is only one feasible solution that satisfies the constraint equations, it does not matter what the objective function is. In the model listed here, we specify real GNP as the maximand. A good test of whether the model is specified correctly is to solve the problem twice, first maximizing GNP and second minimizing GNP. If the CGE model is properly specified, it will have a unique solution and the two solutions should be the same.

Using a nonlinear programming algorithm to solve a "square" model (that is one with as many constraints as variables) seems a bit wasteful. The algorithm MINOS uses to find a feasible basis, however, appears to provide a very robust approach to solving systems of simultaneous nonlinear equations. In the GAMS implementation of MINOS, it is possible to change parameters determining how MINOS operates so as to greatly improve its performance as an equation solver. The new parameters are specified in a file called MINOS5.OPT which GAMS reads when it starts to solve the problem. The MINOS5.OPT file for solving CGE models is listed below:

BEGIN
START ASSIGNED NONLINEARS BASIC
END

The details of how to use the MINOS5.OPT file are described in Appendix D.2 of Brooke, Kendrick, and Meeraus (1988). While changing these parameters usually improves the performance of MINOS in solving CGE models, it may make things worse. If the algorithm fails, try again without using the MINOS5.OPT file.

In doing experiments with the GAMS CGE model, save the base solution and use it as a starting point for doing experiments. In GAMS, a solution can be saved and reused using the "SAVE" and "RESTART" options. See the GAMS manual for details. Specifying this option saves the base-year solution as the initial "guess" for another model. The GAMS programs for doing experiments may then be written in a few lines. One need only specify changes in parameters or exogenous variables and add a new SOLVE statement. Following the SOLVE statement, a list of display statements may be copied from the base-year GAMS program to output results. Given that the entire base solution is stored, one can easily generate "ratio to base" tables by renaming the new results tables and computing ratios to the old tables (which contain the saved original base solution).
STITLE USDA/ERS GAMS U.S. CGE MODEL FOR 1982
SOFSSYM LIST OFFSYM REF OFFUPPER

### U.S. CGE MODEL WITH 1982 DATA BASE, Billions of Dollars.
*USDA/ERS GNP Version, April 1990
*Programmed by: Sherman Robinson, Kenneth Hanson, and Maureen Kilkenny.

*The model is based on GNP data, and includes exports and imports of
*factor services.

*  OMISSIONS: List equations, equations, parameters, and data.

## SET DECLARATION ###################################################################

### SETS

I SECTORS / lvstk dairy and meat
expcrp grains and oilseeds
othcrp other agriculture
agproc agric processing
aginp agric inputs
intmfnf interim manuf
fdmnf final demand manuf
trdtrn trade and transport
service services
resta real estate /

F FACTORS OF PRODUCTION / labor labor
capital capital
land agricultural land /

INS INSTITUTIONS / labr labor
ent enterprises
prop property /

HH HOUSEHOLD TYPE / hhtrn transfer recipients
hhlab wage earners
hhcap rentiers /

* The institution names and the factor names "capital" and "land"
* are referred to explicitly below. If changed, they must also be
* changed where referenced.
* The printing of the GNP accounts assume that there is a sector
* labelled "service."

## SUBSETS DEFINED BELOW: "DEFINE INDEXES"

IAG(I) AG SECTORS / lvstk, expcrp, othcrp /
IAGN(I) NON AG SECTORS

IE(I) EXPORT SECTORS
IED(I) SECTORS WITH EXPORT DEMAND EQN
IEDN(I) SECTORS WITH NO EXPORT DEMAND EQN
IEN(I) NON EXPORT SECTORS

IM(I) IMPORT SECTORS
IMN(I) NON IMPORT SECTORS

ALIAS(I,J) ;

## for SAM
SET ISAM categories
/COMMDTY,ACTIVITY,VALUAD,INSTTNS,HOUSEHOLDS,
GOVT,KACCOUNT,WORLD,TOTAL/
ISAM1(isam) /TOTAL/
ISAM2(isam) ;
ALIAS(isam2,isam3);
PARAMETER SAM(isam,isam) SOCIAL ACCOUNTING MATRIX ;
isam2(isam) = NOT isam1(isam) ;
PARAMETER DECLARATION

### READ IN PARAMETERS

ENTTAX0  ENTERPRISE TAX REVENUE
ENTSAVO  ENTERPRISE SAVINGS
EXR0  EXCHANGE RATE
EO(i)  EXPORTS
FBORO  NET FOREIGN BORROWING
FSAVO  NET FOREIGN SAVINGS
GDTOTO  TOTAL VOLUME OF GOVERNMENT CONSUMPTION
GENTO  PAYMENTS FROM GOVERNMENT TO ENTERPRISES
GOVSAVO  GOVERNMENT SAVINGS
HHSAVO  HOUSEHOLD SAVINGS
HHT0  HOUSEHOLD TRANSFERS
INVESTO  TOTAL INVESTMENT
MO(i)  IMPORTS
MPSO(hh)  HOUSEHOLD MARGINAL PROPENSITY TO SAVE
PDO(i)  DOMESTIC GOODS PRICE
PEO(i)  DOMESTIC PRICE OF EXPORTS
PINDEXO  GNP DEFLATOR
PMO(i)  DOMESTIC PRICE OF IMPORTS
REMTO  NET REMITTANCES FROM ABROAD
SSTAXO  SOCIAL SECURITY TAX REVENUE
TOTHTAXO  HOUSEHOLD TAX REVENUE
XDO(i)  DOMESTIC OUTPUT, VOLUME

### READ IN TABLE FOR INITIALIZATION OF VARIABLES (NEED NOT BE DECLARED)

* TABLE FCTRES1(i,f) FACTOR DEMAND BY SECTOR
* TABLE FCTRY(i,f) FACTOR INCOME BY SECTOR

### READ IN PARAMETERS AS RATES, SHARES, ELASTICITIES

DEPR(i)  DEPRECIATION RATES
DSTR(i)  RATIO OF INVENTORY INVESTMENT TO GROSS OUTPUT
ESR  ENTERPRISE SAVINGS RATE
ETR  ENTERPRISE TAX RATE
GES(i)  GOVERNMENT CONSUMPTION SHARES
HTAX(hh)  HOUSEHOLD TAX RATE
ITAX(i)  INDIRECT TAX RATES
KISH(i)  SHARES OF INVESTMENT BY SECTOR OF DESTINATION
RHSH(hh)  HOUSEHOLD REMITTANCE SHARE
RHOC(i)  ARMINGTON FUNCTION EXPONENT
RHOE(i)  EXPORT DEMAND PRICE ELASTICITY
RHOT(i)  CET FUNCTION EXPONENT
SSTR  SOCIAL SECURITY TAX RATE
TE(i)  EXPORT SUBSIDY RATES
TM(i)  TARIFF RATES ON IMPORTS
THSH(hh)  HOUSEHOLD SHARES OF GOVERNMENT TRANSFERS

### READ IN TABLE OF PARAMETERS (NEED NOT BE DECLARED)

* TABLE CLES(i,hh) HOUSEHOLD CONSUMPTION SHARES
* TABLE IMAT(i,j) CAPITAL COMPOSITION MATRIX
* TABLE IOC(i,j) INPUT-OUTPUT COEFFICIENTS
* TABLE SINTYH(hh,ins) HOUSEHOLD DISTRIBUTION OF INSTITUTIONAL INCOME

### COMPUTED PARAMETERS FROM READ IN DATA (CALIBRATION)

DEPRECIATION TOTAL DEPRECIATION EXPENDITURE
PDO(f)  FACTOR DEMAND, AGGREGATE
FSO(f)  FACTOR SUPPLY, AGGREGATE
INTO(i)  INTERMEDIATE INPUT DEMAND
NETSUBO  EXPORT DUTY REVENUE
PO(i)  PRICE OF COMPOSITE GOOD
PKO(i)  CAPITAL GOODS PRICE BY SECTOR OF DESTINATION
VALUE ADDED PRICE BY SECTOR

WORLD MARKET PRICE OF IMPORTS (IN DOLLARS)

WORLD PRICE OF EXPORTS

AVERAGE OUTPUT PRICE

VALUE ADDED RATE BY SECTOR

FACTOR PRICE SECTORAL PROPORTIONALITY CONSTANTS

FACTOR PRICE, AGGREGATE AVERAGE

DOMESTIC SALES, VOLUME

COMPOSITE GOOD SUPPLY, VOLUME

FACTOR INCOME SUMMED OVER SECTOR

FACTOR INCOME FOR LAND AS FRACTION OF CAPITAL INCOME

FACTOR INCOME BY SECTOR

HOUSEHOLD INCOME

INSTITUTIONAL INCOME

PARAMETERS AS RATES, SHARES

ARMINGTON FUNCTION SHIFT PARAMETER

PRODUCTION FUNCTION SHIFT PARAMETER

FACTOR SHARE PARAMETER-PRODUCTION FUNCTION

CET FUNCTION SHIFT PARAMETER

FACTOR SHARE PARAMETER -PRODUCTION FUNCTION

CET FUNCTION SHARE PARAMETER

PRICE INDEX WEIGHTS

DUMMY VARIABLE FOR COMPUTING A(i)

RATIO OF IMPORTS TO DOMESTIC SALES

SUM OF SHARE CORRECTION PARAMETER

SUM OF SHARE FOR HH CLES

SUM OF SHARE FOR IMAT

REAL EXPORT SUBSIDY RATE IN 1982 DOLLARS

REAL TARIFF RATE IN 1982 DOLLARS

### TABLES USED FOR LOADING VARIABLE RESULTS

TABLE SECTRES(*,i) SECTORAL PRICE AND QUANTITY RESULTS

TABLE FCTRES1(i,f) FACTOR DEMAND RESULTS

TABLE FCTRES2(*,f) FACTOR WAGE, SUPPLY AND INCOME RESULTS

TABLE INSRES(*,ins) INSTITUTIONAL INCOME RESULTS

TABLE HHRES(*,hh) HOUSEHOLD SAVINGS AND INCOME RESULTS

TABLE I0(i,j) INPUT-OUTPUT COEFFICIENTS

<table>
<thead>
<tr>
<th>LVSTK</th>
<th>EXPCRP</th>
<th>OTHCRP</th>
<th>AGPROC</th>
<th>AGINP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.168150</td>
<td>0.028372</td>
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<tr>
<td>0.271862</td>
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TABLE IMAT(i,j) CAPITAL COMPOSITION MATRIX

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<th>OTHCRP</th>
<th>AGPROC</th>
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<tr>
<td>AGPROC</td>
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<td>0.000000</td>
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<td>AGINP</td>
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<td>0.572183</td>
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TABLE FCTRES1(i,f) FACTOR DEMAND BY SECTOR

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<thead>
<tr>
<th></th>
<th>LABOR</th>
<th>CAPITAL</th>
<th>LAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVSTK</td>
<td>0.415354</td>
<td>79.844060</td>
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<tr>
<td>EXPCRP</td>
<td>0.389786</td>
<td>72.290527</td>
<td>342.600000</td>
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<td>OTHCRP</td>
<td>0.495860</td>
<td>27.070413</td>
<td>85.650000</td>
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<tr>
<td>AGPROC</td>
<td>3.584813</td>
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<tr>
<td>AGINP</td>
<td>0.043006</td>
<td>0.011048</td>
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* NOTE, CROPLAND INCOME IS READ AS A FRACTION OF CAPITAL INCOME

TABLE FCTRY(i,f) FACTOR INCOME BY SECTOR

<table>
<thead>
<tr>
<th></th>
<th>LABOR</th>
<th>CAPITAL</th>
<th>LAND</th>
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</thead>
<tbody>
<tr>
<td>LVSTK</td>
<td>4.792637</td>
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<tr>
<td>EXPCRP</td>
<td>3.323859</td>
<td>26.065318</td>
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<td>OTHCRP</td>
<td>4.906739</td>
<td>27.290527</td>
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<td>AGPROC</td>
<td>65.741305</td>
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<td>AGINP</td>
<td>20.248245</td>
<td>31.744451</td>
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* NOTE, CROPLAND INCOME IS READ AS A FRACTION OF CAPITAL INCOME
### Household Parameters

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<thead>
<tr>
<th>Description</th>
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<th>EXPCRP</th>
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<th>AGINP</th>
<th>INTMNF</th>
<th>FDMNF</th>
<th>TRDTRN</th>
<th>SERVICE</th>
<th>RESTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0.003931</td>
<td>0.000326</td>
<td>0.000344</td>
<td>0.024630</td>
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### Institutional Parameters

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<thead>
<tr>
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<th>HHTRN</th>
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<th>HHCAP</th>
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<td>THSH</td>
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</tr>
<tr>
<td>RHSH</td>
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<tr>
<td>HTAX</td>
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<td>0.125960</td>
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<tr>
<td>MPS</td>
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<td>0.061607</td>
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### Production Sector Parameters

<table>
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<th>AGPROC</th>
<th>AGINP</th>
<th>INTMNF</th>
<th>FDMNF</th>
<th>TRDTRN</th>
<th>SERVICE</th>
<th>RESTA</th>
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</thead>
<tbody>
<tr>
<td>Value</td>
<td>77.115329</td>
<td>27.729215</td>
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<td>265.727951</td>
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<td></td>
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</table>

### Summary

- Households and institutions are divided into different sectors and parameters are given for each sector. The table provides consumption shares, administrative procedures, and other economic factors relevant for the study of economic stability and resource allocation.
\* NOTE, TAXES ARE MAGNITUDES AND RATES ARE COMPUTED

**TABLE TAXR(*,I) SECTORAL TAXES**

<table>
<thead>
<tr>
<th>LVSTK</th>
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<th>AGPROC</th>
<th>AGINP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITAX</td>
<td>1.368870</td>
<td>1.276232</td>
<td>0.386298</td>
<td>10.774114</td>
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<tr>
<td>TE</td>
<td>0.008711</td>
<td>0.003304</td>
<td>0.099223</td>
<td>2.746818</td>
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<tr>
<td>TM</td>
<td>1.601493</td>
<td>4.028613</td>
<td>0.049061</td>
<td>0.000400</td>
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</table>

**TABLE PARM(*,I) MISCELLANEOUS PARAMETERS**

<table>
<thead>
<tr>
<th>LVSTK</th>
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<tbody>
<tr>
<td>DEPR</td>
<td>0.108183</td>
<td>0.108183</td>
<td>0.108183</td>
<td>0.095055</td>
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<tr>
<td>DSTR</td>
<td>0.000811</td>
<td>-0.006647</td>
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<tr>
<td>GLES</td>
<td>0.000671</td>
<td>0.011649</td>
<td>0.001061</td>
<td>0.014240</td>
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**PARAMETER SCALRES(*) /**

**## MACRO TOTALS**

<table>
<thead>
<tr>
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<th>EXPCRP</th>
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<tbody>
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<tr>
<td>PINDEX</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GDTOT</td>
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<td></td>
</tr>
<tr>
<td>INVEST</td>
<td>447.300122</td>
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</table>

**## TAX**

<table>
<thead>
<tr>
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<th>AGPROC</th>
<th>AGINP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSTAX</td>
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<td></td>
<td></td>
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<tr>
<td>ENTTAX</td>
<td>63.079602</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>TOTHHTAX</td>
<td>409.335747</td>
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</table>

**## TRANSFER**

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<th>AGINP</th>
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</thead>
<tbody>
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<td>REMIT</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GENT</td>
<td>47.530000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HIT</td>
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<td></td>
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</tr>
<tr>
<td>FBOR</td>
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</tbody>
</table>

**## SAVE**

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</tr>
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<td>HHSAV</td>
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<td>GOVSAM</td>
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<tr>
<td>FSAV</td>
<td>1.029951</td>
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</table>

**## SECTORAL ELASTICITIES**

<table>
<thead>
<tr>
<th>LVSTK</th>
<th>EXPCRP</th>
<th>OTHCRP</th>
<th>AGPROC</th>
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</tr>
</thead>
<tbody>
<tr>
<td>RHOC</td>
<td>4.0</td>
<td>4.0</td>
<td>2.0</td>
<td>0.75</td>
</tr>
<tr>
<td>RHOT</td>
<td>0.5</td>
<td>4.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>
414  RHOE  3.0  3.0  3.0
415  +  INTMNF  FDMNF  TRDTRN  SERVICE  RESTA
416  RHOC  0.75  0.9  1.1  0.2  0.5
417  RHOE  2.0  1.5  2.0  0.6  0.6
418  RHOC
419  RHOE
420  ;
421
422  *######################################################## END PARAMETER ASSIGNMENT ##############################################################
423  *################################################################ SPECIFY PARAMETERS FROM TABLE VALUES #####################################################
424
425  *### PARAMETERS FROM SCALRES(*)
426  ENTSAVO = SCALRES("ENTSAV");
427  ENTTAXO = SCALRES("ENTTAX");
428  EXRO = SCALRES("EXR");
429  FBORO = SCALRES("FBOR");
430  FSARO = SCALRES("FSAV");
431  GDOTOTO = SCALRES("GDOTOT");
432  GENTO = SCALRES("GENT");
433  GOVSARO = SCALRES("GOVSAV");
434  HHSARO = SCALRES("HHSAV");
435  HHTO = SCALRES("HHT");
436  INVESTO = SCALRES("INVEST");
437  PINDEXO = SCALRES("PINDEX");
438  REMITO = SCALRES("REMIT");
439  SSSARO = SCALRES("SSSAX");
440  TOHTHAXO = SCALRES("TOTHHTAX");
441
442  *### OTHER TABLE VALUES OF PARAMETERS
443  EO(i) = SECTRES("EM",i);
444  ECONST(i) = SECTRES("EM",i);
445  MO(i) = SECTRES("MM",i);
446  PXO(i) = SECTRES("PM",i);
447  PED(i) = SECTRES("PE",i)
448  PMO(i) = SECTRES("PM",i);
449  PO(i) = SECTRES("MP",i);
450  PDO(i) = SECTRES("PD",i);
451  PKO(i) = SECTRES("PK",i);
452  XDO(i) = SECTRES("XD",i);
453
454  HTAX(hh) = HHPAR("HTAX",hh);
455  MPSO(hh) = HHPAR("MPS",hh);
456  RHHSH(hh) = HHPAR("RHHSH",hh);
457  THSH(hh) = HHPAR("THSH",hh);
458
459  ITAX(i) = TAXR("ITAX",i)/(PXO(i)*XDO(i));
460
461  RHOC(i) = (1/ELASTICITY("rhoc",i)) - 1;
462  RHOE(i) = ELASTICITY("rhoe",i);
463  RHOE(i) = (1/ELASTICITY("RHOE",i)) + 1;
464
465  DEPR(i) = PARM("DEPR",i);
466  DSTR(i) = PARM("DSTR",i);
467  GLES(i) = PARM("GLES",i);
468  KISH(i) = PARM("KISH",i);
469
470  *### NORMALIZE SHARE PARAMETERS TO CORRECT FOR ROUNDOFF ERROR
471  * These parameters (cles, imat, kish, and gles) can be read in as values
472  * and converted to shares here.
473  SUMSHSH(hh) = SUM(i, CLES(i,hh));
474  CLES(i,hh) = CLES(i,hh)/SUMSHSH(hh);
475  SUMIMSH(i) = SUM(i, IMAT(i,j));
476  IMAT(i,j) = IMAT(i,j)/SUMIMSH(i);
477  SUMMS(hh) = SUM(i, KISH(i,hh));
478  KISH(i) = KISH(i)/SUMMS;
479  SUMSH = SUM(i, GLES(i));
480  GLES(i) = GLES(i)/SUMSH;
## DEFINE INDEXES BASED ON READ IN DATA

1. IAGN(i) = not IAG(i);
2. IE(i) = yes$EO(i);
3. IED(i) = yes$RHOE(i);
4. IEN(i) = not IE(i);
5. IM(i) = yes$M0(i);
6. IMN(i) = not IM(i);

### SPECIFY PARAMETERS WHICH DEPEND ON DEFINED INDEX IM AND IE

1. TM(1m) = 0.0 ;
2. TM(im) = TAXR(‘TM",im)/(PM0(im)*MO(im) - TAXR(‘TM",im)) ;
3. TE(ien) = 0.0 ;
4. TE(ie) = TAXR(‘TE",ie)/(PO(ie)*EO(ie) - TAXR(‘TE",ie)) ;

### COMPUTE FROM INITIAL DATA

1. i = SUM(j I0(i j)*D0(j));
2. PVAO(i) = PX0(i) - SUM(j, I0(j,i)*P0(j)) - ITAX(i) ;
3. PWM(i) = PM0(i)/((1+TM(i))*EXR0);
4. VARO(i) = PVAO(i) + ITAX(i) ;
5. XXDO(i) = XDO(i) - EOM ;

### FOR 1982 TMREAL AND TEREAL ARE DERIVE FROM TM AND TE

1. TMREAL(i) = TM(1)*PWM(i)*EXR0 ;
2. TEREAL(i) = TE(i)*PWE0(i)*EXR0 ;
3. NETSUBO = SUM(i, TE(1)*E0(1)*PWE0(i))*EXR0 ;

### CALIBRATION OF PARAMETERS FROM DATA

1. YFLANDO(i) = FCTRY(i,"land") ;
2. FCTRY(i,"land") = FCTRY(i,"capital")*YFLANDO(i) ;
3. YINSTO(lab") = (1.0 - SSTR)*YFCTRO(1.0 - YFLANDO(1)) ;

### NOTE, HOUSEHOLD INCOME IS FROM FACTORS (YHVAO) AND TRANSFERS

1. YHVAO(hh) = SUM(ins, SINTYH(hh,ins)*YINSTO(ins))
2. YHO(hh) = SUM(ins, SINTYH(hh,ins)*YINSTO(ins)) + REMITO*RHSH(hh)*EXR0 + HHTO*THSH(hh) ;

### COMPUTE HTAX(hhlab) GIVEN OTHER HH TAX RATES AND TOTHHTAXO

1. HTAX("hhlab") = (TOTHHTAXO - HTAX("hhtrn")*YH0("hhtrn") - HTAX("hhcap")*YH0("hhcap")*YHO("hhcap")*(1.0 - HTAX("hhtrn")) ;
2. MPOSO("hhcap") = (HHSADO - MPSO("hhthrn")*YHO("hhthrn")*(1.0 - HTAX("hhthrn")) ;

---

51
552 - MPSO("hhlab")*YHO("hhlab")(1.0-HTAX("hhlab")))  
553 / (YHO("hhcap")*(1.0 - HTAX("hhcap"))) ;  
554  
555 DISPLAY WFDIST, WFO, FS0, YFSECTO, YFCTRO;  
556 DISPLAY YINSTO, YHO, MPSO, HTAX, ETR, ESR, SSTR;  
557  
558 *#### CALIBRATION OF SHIFT AND SHARE PARAMETERS ####  
559  
560 *## FOR IMPORTS - DOMESTIC COMPOSITE  
561 *## get delta from costmin, xo from absorption, ac from armington  
562  
563 DELTA(i) = (PM0(i)/PDO(i))*(M0(i)/XXDO(i))**(1+RHOC(0));  
564 DELTA(i) = DELTA(i)/(1.0+DELTA(i));  
565 XO(i) = (PDO(i)*XXDO(i) + (PM0(i)*M0(i))$im(i))/PO(i);  
566 RMD(i) = M0(i)/XXDO(i);  
567 AC(i)$im(i) = XO(i)/(DELTA(i)*M0(i)**(1-RHOC(i)));  
568 AC(i)$imn(i) = 1.0;  
569 display DELTA, AC, RMD;  
570  
571 *## FOR EXPORTS  
572 *## GET GAMMA FROM SUPPLY  
573 GAMMA(ie) = 1/(1 + PDO(ie)/PEO(ie))*(EO(ie)/XXDO(ie))**(RHOT(ie)-1);  
574 *## GET AT FROM CET  
575 AT(ie) = XDO(ie)/(GAMMA(ie)*EO(ie)**RHOT(ie) + (1-GAMMA(ie))*(1-RHOT(ie))**1/RHOT(ie));  
576 display GAMMA, AT;  
577  
578 *## FOR FACTOR DEMAND  
579 *## GET ALPHA FROM PROFIT MAX (ALPHA FOR EACH i SHOULD SUM TO 1)  
580 ALPHAI(f, i) = (WFDIST(i,f)*WFO(f)*FCTRES1(i,f))/YFSECTO(i);  
581 display ALPHA;  
582  
583 *## get AD from output and FDO from profitmax  
584 QD(i) = PROD(f, FCTRES1(i,f)**ALPHAI(i,f));  
585 AD(i) = XDO(i)/0(i);  
586 FDO(f) = SUM(i, (XDO(i)*PVA0(i)*ALPHAI(i,f)/(WFDIST(i,f)*WFO(f)))$WFDIST(i,f));  
587 display AD, QD, FDO;  
588  
589 *## SPECIFY WEIGHTS FOR PRODUCER PRICE INDEX  
590 PWTS(i) = XDO(i)/SUM(j, XDO(j));  
591  
592 *#### END OF CALIBRATION ####  
593  
594 DISPLAY XDO, XO, XXDO;  
595  
596 VARIABLES  
597 *#### VARIABLE DECLARATION #######  
598  
599 *## PRICE BLOCK  
600 EXR EXCHANGE RATE ($ PER WORLD $)  
601 P(i) PRICE OF COMPOSITE GOODS  
602 PD(i) DOMESTIC PRICES  
603 PE(i) DOMESTIC PRICE OF EXPORTS  
604 PINDEX GNP DEFLATOR  
605 PK(i) PRICE OF CAPITAL GOODS BY SECTOR OF DESTINATION  
606 PM(i) DOMESTIC PRICE OF IMPORTS  
607 PVA(i) VALUE ADDED PRICE  
608 PWEO WORLD PRICE OF EXPORTS  
609 PMO, PWM, TM, PWTS;  
610  
611 VARIABLES  
612 *#### PRODUCTION BLOCK  
613 E(i) EXPORTS ($2 BILL $)  
614 M(i) IMPORTS ($2 BILL $)  
620 X(i) COMPOSITE GOODS SUPPLY ($2 BILL $)
## GNP CALCULATIONS

**GNPV**

\[ \text{Value Added in Market Prices GNP} \]

### FACTOR BLOCK

- **FS(f)**: Factor Supply
- **FDSC(i,f)**: Factor Demand by Sector
- **WF(f)**: Average Factor Price
- **YFCTR(f)**: Factor Income

### INCOME AND EXPENDITURE BLOCK

- **CD(i)**: Final Demand for Private Consumption
- **DEPRE**: Total Depreciation Expenditure
- **DX(i)**: Volume of Investment by Sector of Destination
- **DST(i)**: Inventory Investment by Sector
- **ENTSAV**: Enterprise Savings
- **ENTTAX**: Enterprise Tax Revenue
- **FBOR**: Net Foreign Borrowing
- **FSAV**: Net Foreign Savings
- **FXDINV**: Fixed Capital Investment
- **GD(i)**: Final Demand for Government Consumption
- **GDTOT**: Total Volume of Government Consumption
- **GENT**: Payments from Govt to Ent
- **GOVSAV**: Government Savings
- **GR**: Government Revenue
- **HHSAV**: Total Household Savings
- **HHT**: Household Transfers
- **ID(i)**: Final Demand for Productive Investment
- **INDTAX**: Indirect Tax Revenue
- **INT(i)**: Intermediates Uses
- **INVEST**: Total Investment
- **MPS(hh)**: Marginal Propensity to Save by Household Type
- **NETSUB**: Export Duty Revenue
- **REMIT**: Net Remittances from Abroad
- **SAVINGS**: Total Savings
- **SSTAX**: Social Security Tax Revenue
- **TARIFF**: Tariff Revenue
- **TOTHAX**: Household Tax Revenue
- **YH(hh)**: Household Income
- **YINST(ins)**: Institutional Income

### GNP CALCULATIONS

- **RGNP**: Real GNP
- **GNPV**: Value Added in Market Prices GNP

### VARIABLE INITIALIZATION

- **EXR.L** = EXRO;
- **FBOR.L** = FBORO;
- **FSAV.L** = FSAVO;
- **GDTOT.L** = GDTOTO;
- **GENT.L** = GENTO;
- **GOVSAV.L** = GOVSAVO;
- **HHT.L** = HHTO;
- **INVEST.L** = INVESTO;
- **PINDEX.L** = PINDEXO;
- **REMIT.L** = REMITO;
- **MPS.L(hh)** = MPSO(hh);
- **PD.L(i)** = P00(i);
- **P.L(i)** = PO(i);
- **PX.L(i)** = PX0(i);
- **PM.L(i)** = PMO(i);
- **PE.L(i)** = PED(i);
- **XD.L(i)** = XDO(i);
- **E.L(i)** = EO(i);
- **M.L(i)** = MO(i);
- **FDSC.L(i,f)** = FCTRES1(i,f);
YFCTR.L(f) = SUM(i, FCTRY(i,f)) ;

### COMPUTE INITIAL VALUES FOR OTHER VARIABLES

### OUTPUT AND PRICE

XXD.L(i) = XD.L(i) - E.L(i) ;

X.L(i) = (PD.L(i)*XXD.L(i) + (PM.L(i)*M.L(i))*IM(i))/P.L(i) ;

PK.L(i) = SUM(j, P.L(j)*IMAT(j,i)) ;

PWE.L(i) = PE.L(i)/((1.0 + TE(i))*EXR.L) ;

PWSE(i) = PWE.L(i) ;

PVA.L(i) = PX.L(i) - SUM(j, I0000*P.L(j)) - ITAX(i) ;

### VALUE ADDED AND THE FLOW OF FACTOR INCOME

FS.L(f) = YFCTR.L(f)/FS.L(f) ;

WF.L(f) = SUM(i, FDSC.L(i,f)) ;

NETSUB.L = SUM(i, TE(i)*E.L(i)*PWE.L(i)*EXR.L) ;

TARIFF.L = SUM(i, DEPR(i)*P.L(i)*FDSC.L(i,"capital"))*EXR.L ;

SSTAX.L = SSTR*YFCTR.L("labor") ;

INDTAX.L = SUM(i, ITAX(i)*PX.L(i)*XD.L(i)) ;

DEPRECIA.L = SUM(i, DEPR(i)*P.L(i)*FDSC.L(i,"capital"))*EXR.L ;

ENTTAX.L = ETR*(YFCTR.L("capital") + GENT.L - DEPRECIA.L) ;

ENTSAV.L = ESR*(YFCTR.L("capital") + GENT.L - (ENTTAX.L + DEPRECIA.L)) ;

YINST.L("lab") = YFCTR.L("labor") - SSTAX.L ;

YINST.L("ent") = YFCTR.L("capital") + GENT.L - (ENTTAX.L + DEPRECIA.L) ;

YINST.L("prop") = YFCTR.L("land") ;

YH.L(hh) = SUM(ins, SINITY(hh,ins)*YINST.L(ins)) ;

+ REMIT.L*RHS(hh)*EXR.L + HHT.HALF(hh) ;

TOTHHTAX.L = SUM(hh, HTAX(hh)*YH.L(hh)) ;

+ ENTSAV.L + FBOR.L*EXR.L ;

SAVINGS.L = HHSAV.L + GOVSAV.L + DEPRECIA.L + FSAV.L*EXR.L + ENTSAV.L ;

### FINAL DEMAND

INT.L(i) = SUM(j, IO(i,j)*XD.L(j)) ;

CD.L(i) = SUM(hh, CLES(i,hh)*(1.0 - MPS.L(hh))*YH.L(hh) ;

*(1.0 - HTAX(hh))/P.L(i) ;

GD.L(i) = GLES(i)*GDTOT.L ;

DST.L(i) = DSTR(i)*XD.L(i) ;

FXDINV.L = INVEST.L - SUM(i, DST.L(i)*P.L(i)) ;

DK.L(i) = (KISH(i)*FXDINV.L)/PK.L(i) ;

ID.L(i) = SUM(j, IMAT(i,j)*DK.L(j)) ;

GR.L = TARIFF.L - NETSUB.L + INDTAX.L + TOTHHTAX.L + SSTAX.L + ENTTAX.L + FBOR.L*EXR.L ;

SAVINGS.L = HHSAV.L + GOVSAV.L + DEPRECIA.L + FSAV.L*EXR.L + ENTSAV.L ;

### GNP

GNPVA.L = SUM(i, PVA.L(i)*XD.L(i)) + INDTAX.L + TARIFF.L - NETSUB.L ;

RGNP.L = SUM(i, CD.L(i) + DST.L(i) + ID.L(i) + GD.L(i)) ;

+ SUM(i, TE(i)*E.L(i)) ;

+ SUM(i, (1.0 - TEREAL(i))*E.L(i)) ;

+ SUM(i, (1.0 - TMREAL(i))*M.L(i)) ;

+ REMIT.L*RHS(hh)*EXR.L + HHT.HALF(hh) ;

PINDEX.L = GNPVA.L/RGNP.L ;

### ALTERNATIVELY, SET PINDEX TO THE PRODUCER PRICE INDEX

PINDEX.L = SUM(i, pwts(i)*PX(i)) ;

DISPLAY YFCTR.L,YINST.L,YH.L,GNPVA.L,RGNP.L,PINDEX.L ;

DISPLAY INT.L,CD.L,GD.L,ID.L,DST.L,DK.L ;

### END VARIABLE SPECIFICATION

#### TO CHECK FOR DATA CONSISTENCY, DISPLAY INITIAL SAM

SAM("COMMDDTY","ACTIVITY") = SUM(i,(P.L(i)*INT.L(i)) ;

SAM("COMMDDTY","HOUSEHOLDS") = SUM(i,(P.L(i)*CD.L(i)) ;

SAM("COMMDDTY","KACCOUNT") = SUM(i,(P.L(i)*(DST.L(i)+ID.L(i)))) ;

SAM("COMMDDTY","GOVT") = SUM(i,(P.L(i)*GD.L(i)) ;

SAM("ACTIVITY","WORLD") = SUM(i,(EXR.L*PWE.L(i)*E.L(i)) ;

SAM("ACTIVITY","COMMDDTY") = SUM(i, (PX.L(i)*XD.L(i)) ;
OPTION DECIMALS=2;
DISPLAY SAM;
OPTION DECIMALS=3;

*####################################################################
EQUATIONS
*#################### EQUATION DECLARATION ###########################

PMDEF(i)
PEDEF(i)
ABSORPTION(i)
SALES(i)
ACTP(i)
PKDEF(i)

PMDEF(i)
PEDEF(i)
ABSORPTION(i)
SALES(i)
ACTP(i)
PKDEF(i)

OPTION DECIMALS=2;
DISPLAY SAM;
OPTION DECIMALS=3;

*####################################################################
EQUATIONS
*#################### EQUATION DECLARATION ###########################

PMDEF(i)
PEDEF(i)
ABSORPTION(i)
SALES(i)
ACTP(i)
PKDEF(i)
DEPREQ  DEPRECIATION EXPENDITURE
ESAVE  ENTERPRISE SAVINGS
HHSAVEQ  HOUSEHOLD SAVINGS
GREQ  GOVERNMENT REVENUE
TOTSAv  TOTAL SAVINGS
**EXPENDITURE**
CDEQ(i)  PRIVATE CONSUMPTION BEHAVIOR
GDEQi(i)  GOVT CONSUMPTION OF COMMODITIES
GRUSE  GOVERNMENT SAVINGS
DSTEQ(i)  INVENTORY INVESTMENT
FIXEDINV  FIXED INVESTMENT NET OF INVENTORY
PRODINV(i)  INVESTMENT BY SECTOR OF DESTINATION
IEQ(i)  INVESTMENT BY SECTOR OF ORIGIN
**MARKET CLEARING**
EQUIL(i)  GOODS MARKET EQUILIBRIUM
FMEQUIL(f)  FACTOR MARKET EQUILIBRIUM
CAEQ  CURRENT ACCOUNT BALANCE (BILL DOLLARS)
*WALRAS  SAVINGS INVESTMENT EQUILIBRIUM
**The WALRAS equation is redundant,**
**given that the model satisfies Walras' Law.**
**In this case, we drop the Savings-Investment balance equation.**
**GROSS NATIONAL PRODUCT**
GNPY  TOTAL VALUE ADDED INCLUDING INDTAX
GNPR  REAL GNP
**PRICE BLOCK**
PMDEF(im)..  PM(im) =E= PWM(im)*EXR*(1 + TM(im)) ;
PEDEF(ie)..  PE(ie) =E= PWE(ie)*PM(ie) + TE(ie))*EXR ;
ABSORPTION(i).  P(i)*X(i) =E= PD(i)*XXD(i) + PM(i)*M(i)*Im(i) ;
SALES(i).  PX(i)*XD(i) =E= PD(i)*XXD(i) + PE(i)*E(i)*ie(i) ;
ACTP(i).  PVA(i) =E= PX(i)*(1 - ITAX(i)) - SUM(J, I0(i,j)*XD(j)) ;
PKDEF(i).  PK(i) =E= SUM(J, P(i)*Im(J,i)) ;
PINDEXDEF  PINDEX =E= GNPVA/RGNP ;
**PRODUCTION BLOCK**
ACTIVITY(i).  XD(i) =E= AD(i)*PROD*(i)**ALPHA (i,f) ;
PROFITMAX(i,f)*WFDIST(i,f) =E= WF(f)*XXD(i,f)*FDSC(i,f) =E=
INT(i).  INT(i) =E= SUM(J, IO(i,j)*XD(j)) ;
CET(i).  XD(i) =E = AT(i)*E(i)**RHYT(i,e)*RHYT(i,e) +
(1 - GAMMA(i))**XXD(i,e)**RHYT(i,e)**(1/RHYT(i,e)) ;
CET2(ien).  XD(ien) =E = XXD(ien) ;
ESUPPLY(i).  E(i) =E = XXD(i,e)*PD(i,e) ;
EDEMAND(i).  E(i) =E = ECONST(i)*PWE(i)/PWSE(i)** RHOE(i,e) ;
ARMINGTON(im).  X(im) =E = AC(im)*DELTA(im)*M(im)**RHOE(im) +
(1 - DELTA(im))*XXD(im)**(-RHOC(im))**(-1/RHOC(im));

ARMINGTON2(imn) .. X(imn) =E= XXD(imn);

COSTMIN(imn) .. M(im)/XXD(imn) =E= (PD(im)/PM(im)*DELTA(im)/(1 - DELTA(im)))**(1/(1 + RHOC(im)));

*## INCOME BLOCK

YFCTREQ(f) .. YFCTR(f) =E= SUM(i, WF(f)*WFDIST(i,f)*FDSC(i,f));

LABORY .. YINST("labor") =E= YFCTR("labor") - SSTAX;

PROPY .. YINST("prop") =E= YFCTR('1 land");

ENTY .. YINST("ent") =E= YFCTR("capital") + GENT - (ENTSAV + ENTTAX + DEPRECIA);

HHY(hh) .. YH(hh) =E= SUM(ins, SINTYH(hh,ins)*YINST(ins)) + REMIT*RHSH(hh)*EXR + HHT*THSH(hh);

TARIFDEF .. TARIFF =E= SUM(im, TM(im)*M(im)*PWM(im))*EXR;

INDTAXDEF .. INDTAX =E= SUM(i, ITAX(i)*PX(i)*XD(i));

NETSUBDEF .. NETSUB =E= SUM(ie, TE(ie)*E(ie)*PWE(ie))*EXR;

TARIFFDEF .. TARIFF =E= SUM(im, TM(im)*M(im)*PWM(im))*EXR;

NETSUBDEF .. NETSUB =E= SUM(ie, TE(ie)*E(ie)*PWE(ie))*EXR;

TAXSS .. SSTAX =E= SSTR*YFCTR(hllabor");

ETAX .. ENTTAX =E= ETR*(YFCTR("capital") - DEPRECIA + GENT);

HHTAXDEF .. TOTHHTAX =E= SUM(hh, HTAX(hh)*YH(hh));

DEPREQ .. DEPRECIA =E= SUM(i, DEPR(i)*PK(i)*FDSC(i,"capital"));

ESAVE .. ENTSAV =E= ESR*(YFCTR("capital") + GENT-ENTTAX-DEPRECIA);

HHSAVEQ .. HHSAV =E= SUM(hh, MPS(hh)*YH(hh)*(1 - HTAX(hh)));

GREQ .. GR =E= TARIFF - NETSUB + INDTAX + TOTHHTAX + SSTAX + ENTTAX + FSAV*EXR;

TOTSAV .. SAVINGS =E= HHSAV + GOVSAV + DEPRECIA + FSAV*EXR + ENTSAV;

*## EXPENDITURE BLOCK

CDEQ(i) .. P(i)*CD(i) =E= SUM(hh, CLES(i,hh)*(1-MPS(hh))*YH(hh)*(1-HTAX(hh)));

GDEQ(i) .. GD(i) =E= GLES(i)*GDTOT;

GRUSE .. GR =E= SUM(i, P(i)*GD(i)) + GOVSAV + GENT + HHT;

DSTEQ(i) .. DST(i) =E= DSTR(i)*XD(i);

FIXEDINV .. FXDINV =E= INVEST - SUM(i, DST(i)*P(i));

PRODINV(i) .. PK(i)*DK(i) =E= KISH(i)*FXDINV;

IEQ(i) .. ID(i) =E= SUM(J, IMAT(i,j)*DK(j));

*## MARKET CLEARING

EQUIL(i) .. X(i) =E= INT(i) + CD(i) + GD(i) + ID(i) + DST(i);

FMEQUIL(f) .. SUM(i, FDSC(i,f)) =E= FS(f);

CAEQ .. SUM(im, PWM(im)*M(im)) =E= SUM(ie, PWE(ie)*E(ie)) + FSAV + REMIT + FBOR;
SAVINGS =\ E\ INVEST ;

*** GROSS NATIONAL PRODUCT
GNPV = \sum(i,PVA(i)\times XD(i)) + INDTAX + TARIFF - NETSUB ;
GNPR = \sum(i,CD(i) + DST(i) + ID(i) + GD(i))
+ \sum(ie,(1.0 - TEREAL(ie)) \times E(ie))
- \sum(im,(1.0 - TMREAL(im)) \times M(im)) ;

*** ADDITIONAL RESTRICTIONS CORRESPONDING TO EQUATIONS
PMDEF, PEDEF, EDEMAND, ESUPPLY, COSTMIN, AND PROFITMAX
FOR NON-TRADED SECTORS AND SECTORS WITH FIXED WORLD EXPORT PRICES
PM.FX(imn) = PM0(imn) ;
PE.FX(ien) = PEO(ien) ;
PWE.FX(iedn) = PWE.L(iedn) ;
E.FX(ien) = 0;
M.FX(imn) = 0;
FDSC.FX(i,f) \times (WFDIST(i,f) EQ 0) = 0 ;

*** VARIABLE BOUNDS
These are included to improve algorithm performance. They are not necessary for model specification.
P.LO(i) = 0.0 ;
PD.LO(i) = 0.0 ;
PM.LO(im) = 0.0 ;
PK.LO(i) = 0.0 ;
PX.LO(i) = 0.0 ;
X.LO(i) = 0.0 ;
XD.LO(i) = 0.0 ;
M.LO(im) = 0.0 ;
XXD.LO(i) = 0.0 ;
WF.LO(f) = 0.0 ;
INT.LO(i) = 0.0 ;
E.LO(ie) = 0.0 ;
FDSC.LO(i,f) \times (FDSC.L(i,f) NE 0) = 0 ;
PVA.LO(i) = 0.0 ;

MODEL CLOSURE

FOREIGN EXCHANGE MARKET CLOSURE
In this version, the balance of trade (current account balance) is fixed exogenously and the exchange rate is the equilibrating variable.
EXR.FX = EXR.L ;
FSAV.FX = FSAV.L ;
REMIT.FX = REMIT.L ;
FBOR.FX = FBOR.L ;

INVESTMENT-SAVINGS CLOSURE
This version specifies neoclassical closure. Aggregate investment is determined by aggregate savings; the model is savings driven.
MPS.FX(hh) = MPS.L(hh) ;
INVEST.FX = INVEST.L ;

EXOGENOUS GOVT EXPENDITURE
AND GOVT CLOSURE RULE
Real government spending (GDTOT) is fixed exogenously. The government deficit (GOVSAV) is determined residually.
GDTOT.FX = GDTOT.L ;
GENT.FX = GENT.L ;
HHT.FX = HHT.L ;
GOVSAV.FX = GOVSAV.L ;

FACTOR MARKET CLOSURE
In this version, all factors, including capital, are mobile.
Commented equations allow a version with fixed wage for labor.
The model then solves for aggregate employment.
FS.FX(f) = FS.L(f) ;
WF.FX("labor") = WF.L("labor") ;
FS.LO("labor") = -inf ;
FS.UP("labor") = +inf ;
**## NUMERAIRE PRICE INDEX**

In this case, the GNP deflator.

PINDEX.FX = PINDEX.L;

END OF MODEL

OPTIONS ITERLIM=1000,LIMROW=0,LIMCOL=0,SOLPRINT=OFF;

MODEL US82 /ALL/;

SOLVE US82 Maximizing RGNP USING NLP;

*### 1) TABLES OF RESULTS FOR VARIABLES IN THE MODEL*

**## MACRO AGGREGATE RESULTS**

SCALRES("EXR") = EXR.L;

SCALRES("PINDEX") = PINDEX.L;

SCALRES("RGNP") = RGNP.L;

SCALRES("GNPVA") = GNPVA.L;

SCALRES("INVEST") = INVEST.L;

SCALRES("FXDINV") = FXDINV.L;

SCALRES("GDTOT") = GDTOT.L;

SCALRES("GR") = GR.L;

SCALRES("SSTAX") = SSTAX.L;

SCALRES("TARIFF") = TARIFF.L;

SCALRES("INDTAX") = INDTAX.L;

SCALRES("ENTTAX") = ENTTAX.L;

SCALRES("TOTHHTAX") = TOTHHTAX.L;

SCALRES("NETSUB") = NETSUB.L;

SCALRES("REMIT") = REMIT.L;

SCALRES("GENT") = GENT.L;

SCALRES("HHT") = HHT.L;

SCALRES("FBOR") = FBOR.L;

SCALRES("SAVINGS") = SAVINGS.L;

SCALRES("ENTSAV") = ENTSAV.L;

SCALRES("DEPRECIA") = DEPRECIA.L;

SCALRES("HHSAV") = HHSAV.L;

SCALRES("GOVSAV") = GOVSAV.L;

SCALRES("FSAV") = FSAV.L;

**## FACTOR OF PRODUCTION RESULTS**

FCTRES1(i,f) = FDSC.L(i,f);

**## TABLE FCTRES2(*,f) MISCELLANEOUS FACTOR VARIABLE RESULTS**

SET IFVAR /WF, FS, YFCTR/ ;

PARAMETER FCTRES2(IFVAR,f) . MISCELLANEOUS FACTOR VARIABLE RESULTS

FCTRES2("WF",f) = WF.L(f);

FCTRES2("FS",f) = FS.L(f);

FCTRES2("YFCTR",f) = YFCTR.L(f);

**## SECTORAL PRICE AND QUANTITY RESULTS**

SECTRES("P",i) = P.L(i);
SECTRES("PD",i) = PD.L(i) ;
SECTRES("PE",i) = PE.L(i) ;
SECTRES("PK",i) = PK.L(i) ;
SECTRES("PM",i) = PM.L(i) ;
SECTRES("PVA",i) = PVA.L(i) ;
SECTRES("PWE",i) = PWE.L(i) ;
SECTRES("PWE",i) = PWE.L(i) ;
SECTRES("PX",i) = PX.L(i) ;
SECTRES("X",i) = X.L(i) ;
SECTRES("XD",i) = XD.L(i) ;
SECTRES("XXD",i) = XXD.L(i) ;
SECTRES("E",i) = E.L(i) ;
SECTRES("M",i) = M.L(i) ;
SECTRES("INT",i) = INT.L(i) ;
SECTRES("CD",i) = CD.L(i) ;
SECTRES("GD",i) = GD.L(i) ;
SECTRES("ID",i) = ID.L(i) ;
SECTRES("DST",i) = DST.L(i) ;
SECTRES("DK",i) = DK.L(i) ;

*0 INSTITUTIONAL RESULTS
## TABLE INSRES(*,ins) INSTITUTIONAL INCOME RESULTS
SET INSVAR /YINST/ ;
PARAMETER INSRES(insvar,ins) INSTITUTIONAL INCOME RESULTS ;
INSRES("YINST",ins) = YINST.L(ins) ;

*0 HOUSEHOLD RESULTS
## TABLE HHRES(*,hh) MISCELLANEOUS HOUSEHOLD RESULTS
SET HHVAR IMPS, YH/ ;
PARAMETER HHRES(hhvar,hh) MISCELLANEOUS HOUSEHOLD RESULTS ;
HHRES("MPS",hh) = MPS.L(hh) ;
HHRES("YH",hh) = YH.L(hh) ;

option decimals = 6 ;
DISPLAY SCALRES, FCTRES1, FCTRES2, SECTRES, INSRES, HHRES ;
option decimals = 3 ;

### 2) TABLES OF RESULTS FOR DISPLAY
### DEFINE SETS FOR SOLUTION REPORT TABLES ###
* For GNP TABulations
SET ignp rows /consmp, Investment, Inventory, Government, Exports, Imports, GNP /
ignp1(ignp) /gnp/
ignp2(ignp)
ignp columns /nominal
real
nomshare
realshare
deflator / ;
ignp2(ignp) = NOT ignp1(ignp) ;

PARAMETER gnptab(ignp,gnp) GNP ACCOUNTS ;
PARAMETER gnptab2(i,gnp) SECTORAL VALUE ADDED ;
PARAMETER sumgnp(gnp) AGGREGATE GNP ;
PARAMETER gnpratio GNP value added correction factor ;

* for ABSORB
set rar rows / ag, non-ag, total /
PARAMETER ABSORB(rar,rac) ABSORPTION TABLE (REAL) ;

* for FACTORS
set rf / yf, yfcap, profit, rental, rdist, wdcap, yflabor, wdlabor, yfland, wdland, pint, intinp /
PARAMETER FACTORS(i,rf) FACTOR RETURNS DISTRIBUTIVE PARAMETERS ;
* for COEFFS (shift and share coefficients)
set rc / ALPHAL, ALPHAC, ALPHAP, RMD, DELTA, AD /
PARAMETER COEFFS(i,rc) SHIFT, SHARE AND DISTRIBUTIVE PARAMETERS;

**## DEFINE EXTRA PARAMETERS FOR SOLUTION REPORT TABLES ##**
PARAMETERS
agtotfd agricultural terms of trade
agtotva ag terms of trade value added
agtotme ag terms of trade world export price
agtotmi ag terms of trade world import price
avgprofit average profit rate
avgwf average factor price current weights
bot nominal balance of trade
botr real balance of trade
colind cost of living index
esum real exports
extrind real exchange rate index
hold1 holds value for end calculation
indhold holds value for end calculation
intinp(i) intermediate input demand by sector i
intinpn(i) nominal intermediate input demand by sector i
msum real imports
ncdtot nominal cdtot
nex nominal exports
nim nominal imports
ngdtot nominal govt demand
ngnp nominal GNP
pgind = SUM(iag,px.l(iag)*xd.l(iag))/SUM(iag,xd.l(iag));
pgind = SUM(iag,pva.l(iag)*xd.l(iag))/SUM(iag,xd.l(iag));

## AG TERMS OF TRADE ##
pagind = SUM(iag,pagind)*xd.l(iag)/SUM(iag,xd.l(iag));

---

*## AG TERMS OF TRADE ##*

### SPECIFY EXTRA PARAMETERS FOR SOLUTION REPORT TABLES ###

---

*## AG TERMS OF TRADE ##*

pagind = SUM(iag,pagind)*xd.l(iag)/SUM(iag,xd.l(iag));

---

*## AG TERMS OF TRADE ##*

pagind = SUM(iag,pagind)*xd.l(iag)/SUM(iag,xd.l(iag));

---

*## AG TERMS OF TRADE ##*

pagind = SUM(iag,pagind)*xd.l(iag)/SUM(iag,xd.l(iag));

---

*## AG TERMS OF TRADE ##*
agtotva = 100*pagind/pnagind;
pagind = SUM(iag,pwe.l(iag)*e.l(iag))/SUM(iag,e.l(iag));
pgm = SUM(iag,pwm(iag)*m.l(iag))/SUM(iag,m.l(iag));
pgm = SUM(iag,pwm(iag)*m.l(iag))/SUM(iag,m.l(iag));
agtote = 100*pagind/pnagind;
pgm = SUM(iag,pwm(iag)*m.l(iag))/SUM(iag,m.l(iag));
agtote = 100*pagind/pnagind;

DISPLAY agtotfd, agtotva, agtotm, agtote;

**# MACRO BALANCES**
ncdot = SUM(i,cd.l(i)*p.l(i));
ngdttot = SUM(i,gd.l(i)*p.l(i));
ngnp = SUM(i,p.l(i)*(cd.l(i) + dst.l(i) + id.l(i) + gd.l(i))
+ pe.l(i)*e.l(i) - pwm(i)*exr.l*m.l(i));
nex = SUM(i,ie.l(i)*e.l(i)/p.l(i));
nim = SUM(i,im.l(i)*exr.l*pm.l(i));
bot = nex-nim;
bot = SUM(i,ie.l(i)) / SUM(i,m.l(i));
esum = SUM(i,e.l(i));
msum = SUM(i,m.l(i));
psav = invest.l - fsav.l - govsav.l;
shbot = 100*bot/gnpva.l;
shconsump = 100*ncdotot/gnpva.l;
shex = 100*shbot/gnpva.l;
shfsav = 100*fsav.l/gnpva.l;
shinvest = 100*invest.l/gnpva.l;
shgdtot = 100*ngdtot/gnpva.l;
shgsav = 100*govsav.l/gnpva.l;
shpsav = 100*psav/gnpva.l;

**INDEXES**
COLIND = SUM(i,p.l(i)*(SUM(j,cles(i,j)))/CARD(hh));
WTD = XXD(j)/SUM(i,XXD(i));
WM = SUM(i,MO(i))/SUM(i,MO(i)+EO(i));
WTX = EO(i)/SUM(i,MO(i)+EO(i));
EXRIND = SUM(i,WBD(i)*PD.L(i))
/SUM(i,(WBD(i)*PD.L(i))+(WBD(i)*PD.L(i)))*100;

**SPECIFY SOLUTION REPORT TABLES**

**# Important Notes**
- Note that cost of living index (COLIND) is the simple average over households. CARD(hh) is the "cardinal" function which counts number of entries in the set.
- Note that real GNP from expenditure side provides the control total, and sectoral real value addeds are adjusted to match total using gnpratio.
1311 gnptab("consmp","nominal") = SUM(i,p.l(i)*cd.l(i)) ;
1312 gnptab("consmp","real") = SUM(i,cd.l(i));
1313 gnptab("investment","nominal") = SUM(i,p.l(i)*id.l(i));
1314 gnptab("investment","real") = SUM(i,id.l(i));
1315 gnptab("inventory","nominal") = SUM(i,p.l(i)*dst.l(i));
1316 gnptab("inventory","real") = SUM(i,dst.l(i));
1317 gnptab("government","nominal") = SUM(i,p.l(i)*gd.l(i));
1318 gnptab("government","real") = SUM(i,gd.l(i));
1319 gnptab("exports","nominal") = SUM(i,pweel(i)*e.l(i))*exr.l;
1320 gnptab("exports","real") = SUM(i,(1.0 - tereal(i))*e.l(i)) ;
1321 gnptab("imports","nominal") = -SUM(i,pwm(i)*m.l(i))*exr.l ;
1322 gnptab("imports","real") = -SUM(i,(1.0 - tmreal(i))*m.l(i));
1323 gnptab("gni","nominal") = SUM(ignp2,gnptab(ignp2,"nominal")) ;
1324 gnptab("gni","real") = SUM(ignp2,gnptab(ignp2,"real"));
1325 gnptab(ignp,"nomshare") = 100.*gnptab(ignp,"nominal") ;
1326 gnptab(ignp,"realshare") = 100.*gnptab(ignp,"real") ;
1327 gnptab(ignp,"deflator") = 100.*gnptab(ignp,"nominal") \ /
1328 gnptab(ignp,"real") ;
1329 gnptab2(i,"nominal") = pva.l(i)*xd.l(i) + itax(i)*px.l(i)*xd.l(i) -
1330 te(i)*pwe.l(i)*e.l(i)*exr.l ;
1331 gnptab2("service","nominal") = gnptab2("service","nominal") + tariff.l ;
1332 gnptab2(i,"real") = var0(i)*xd.l(i) ;
1333 gnptab2("service","real") = gnptab2("service","real") +
1334 SUM(i,(1.0 - tmreal(i))*m.l(i));
1335 sumgnp("nominal") = SUM(i,gnptab2(i,"nominal")) ;
1336 sumgnp("real") = SUM(i,gnptab2(i,"real"));
1337 gnpratio = gnptab("gni","real")/sumgnp("real") ;
1338 gnptab20(i,"nominal") = gnpratio*gnptab2(i,"nominal") ;
1339 sumgnp("real") = SUM(i,gnptab20(i,"nominal"))/gnptab2(i,"real") ;
1340 gnptab2(i,"nomshare") = 100*gnptab2(i,"nominal")/sumgnp("nominal") ;
1341 gnptab2(i,"realshare") = 100*gnptab2(i,"real")/sumgnp("real") ;
1342 sumgnp("nomshare") = SUM(i,gnptab2(i,"nomshare"));
1343 sumgnp("realshare") = SUM(i,gnptab2(i,"realshare")) ;
1344 gnptab2(i,"deflator") = 100.*gnptab20(i,"nominal")/gnptab20(i,"real") ;
1345 DISPLAY GNPTAB, GNPTAB2, SUMGNP, GNPRATIO ;
1346
1347 *** REPORT ABSORPTION ***
1348 absorb("ag","c") = SUM(iag,CD.L(iag)) ;
1349 absorb("non-ag","c") = SUM(iagn,CD.W(iagn)) ;
1350 absorb("total","c") = SUM(i,CD.l(i));
1351 absorb("ag","i") = SUM(iag,CD.L(iag)) ;
1352 absorb("non-ag","i") = SUM(iagn,CD.W(iagn)) ;
1353 absorb("total","i") = SUM(i,CD.l(i));
1354 absorb("ag","M") = SUM(iag,CD.L(iag)) ;
1355 absorb("non-ag","M") = SUM(iagn,CD.W(iagn)) ;
1356 absorb("total","M") = SUM(i,CD.l(i));
1357 absorb("ag","E") = SUM(iag,CD.L(iag)) ;
1358 absorb("non-ag","E") = SUM(iagn,CD.W(iagn)) ;
1359 absorb("total","E") = SUM(i,CD.l(i));
1360 absorb("ag","M11") = SUM(iag,CD.L(iag)) ;
1361 absorb("non-ag","M11") = SUM(iagn,CD.W(iagn)) ;
1362 absorb("total","M11") = SUM(i,CD.l(i));
1363 absorb("ag","NETE-M") = SUM(iag,CD.L(iag)) ;
1364 absorb("non-ag","NETE-M") = SUM(iagn,CD.W(iagn)) ;
1365 absorb("total","NETE-M") = SUM(i,CD.l(i));
1366 absorb("ag","GNP") = SUM(iag,CD.L(iag)) ;
1367 absorb("non-ag","GNP") = SUM(iagn,CD.W(iagn)) ;
1368 absorb("total","GNP") = SUM(i,CD.l(i));
1369 absorb("ag","absorb") = SUM(iag,CD.L(iag)) ;
1370 absorb("non-ag","absorb") = SUM(iagn,CD.W(iagn)) ;
1371 absorb("total","absorb") = SUM(i,CD.l(i));
1372 DISPLAY ABSORB ;
1373
1374 DISPLAY GNPTAB, GNPTAB2, SUMGNP, GNPRATIO ;
1375
1376 *** REPORT ABSORPTION ***
1377 absorb("ag","c") = SUM(iag,CD.L(iag)) ;
1378 absorb("non-ag","c") = SUM(iagn,CD.W(iagn)) ;
1379 absorb("total","c") = SUM(i,CD.l(i));
1380 absorb("ag","i") = SUM(iag,CD.L(iag)) ;
1381 absorb("non-ag","i") = SUM(iagn,CD.W(iagn)) ;
1382 absorb("total","i") = SUM(i,CD.l(i));
1383 absorb("ag","M") = SUM(iag,CD.L(iag)) ;
1384 absorb("non-ag","M") = SUM(iagn,CD.W(iagn)) ;
1385 absorb("total","M") = SUM(i,CD.l(i));
1386 absorb("ag","E") = SUM(iag,CD.L(iag)) ;
1387 absorb("non-ag","E") = SUM(iagn,CD.W(iagn)) ;
1388 absorb("total","E") = SUM(i,CD.l(i));
1389 absorb("ag","M11") = SUM(iag,CD.L(iag)) ;
1390 absorb("non-ag","M11") = SUM(iagn,CD.W(iagn)) ;
1391 absorb("total","M11") = SUM(i,CD.l(i));
1392 absorb("ag","NETE-M") = SUM(iag,CD.L(iag)) ;
1393 absorb("non-ag","NETE-M") = SUM(iagn,CD.W(iagn)) ;
1394 absorb("total","NETE-M") = SUM(i,CD.l(i));
1395 absorb("ag","GNP") = SUM(iag,CD.L(iag)) ;
1396 absorb("non-ag","GNP") = SUM(iagn,CD.W(iagn)) ;
1397 absorb("total","GNP") = SUM(i,CD.l(i));
1398 absorb("ag","absorb") = SUM(iag,CD.L(iag)) ;
1399 absorb("non-ag","absorb") = SUM(iagn,CD.W(iagn)) ;
1400 absorb("total","absorb") = SUM(i,CD.l(i));
1401 DISPLAY ABSORB ;
*### calculate and report selected parameters and coefficients #########

\[ \text{INTINP}(j) = \sum(i, I_0(i,j) \times XD.L(j)) \]
\[ \text{INTINPN}(j) = \sum(i, P.L(i) \times I_0(i,j) \times XD.L(j)) \]
\[ \text{PINT}(i) = \sum(j, IO(J,i) \times P.L(j)) \]
\[ \text{YF}(i,f) = WFDIST(i,f) \times WF.L(f) \times FDSC.L(i,f) \]
\[ \text{PROFIT}(i) = \frac{(WFDIST(i,"capital") \times WF.L("capital") \times FDSC.L(i,"capital"))}{FDSC.L(i,"capital") \times PK.L(i)} \]
\[ \text{AVGPROFIT} = \sum(I, WFDIST(i,"capital") \times WF.L("capital") \times FDSC.L(i,"capital") \times PK.L(i)) \]
\[ \text{AVGWF}(f) = YFCTR.L(f)/FS.L(f) \]
\[ \text{RENTAL}(i) = \frac{(WFDIST(i,"capital") \times WF.L("capital") \times FDSC.L(i,"capital"))}{FDSC.L(i,"capital")} \]
\[ \text{RDIST}(i) = \frac{\text{RENTAL}(i)}{\text{AVGWF}("capital")} \]
\[ \text{VALADD}(i) = (PVA.L(04-(ITAX(i) \times PX.L(i)) \times XD.L(i)) \]
\[ \text{SECTORY}(i) = (PVA.L(i)) \times XD.L(i) \]
\[ \text{RMD}(i) = M.L(i) / XXD.L(i) \]

DISPLAY AVGWF, AVGPROFIT, VALADD, SECTORY

FACTORS(i,"YF")
FACTORS(i,"YFCAP")
FACTORS(i,"PROFIT")
FACTORS(i,"RENTAL")
FACTORS(i,"RDIST")
FACTORS(i,"WDCAP")
FACTORS(i,"YFLABOR")
FACTORS(i,"WDLABOR")
FACTORS(i,"YFLAND")
FACTORS(i,"WDLAND")
FACTORS(i,"PINT")
FACTORS(i,"INTINP")

COEFFS(i,"ALPHAL")
COEFFS(i,"ALPHAP")
COEFFS(i,"ALPHAC")
COEFFS(i,"RMD")
COEFFS(i,"DELTA")
COEFFS(i,"AD")

DISPLAY FACTORS, COEFFS

*### 3) TABLES OF RESULTS FOR RESTART SOLUTION RATIO TABLES

**### DEFINE SETS FOR RESTART SOLUTION RATIO TABLES ###

for SCALRES1, SCALRES2, RSCALE

\[ \text{SET sc / EXR, PINDEX, RGNP, GNPVA, INVEST, FXDINV, GDTOT,} \]
\[ \text{GR, SSTAX, TARIFF, INDTAX, TOTHHTAX, NETSUB,} \]
\[ \text{REMIT, GENT, HIT, FBOR, SAVINGS, ENTSAV, DEPRECIA,} \]
\[ \text{HHSAV, GOVSAV, FSAV /} \]

PARAMETER SCALRES1(sc) AGGREGATE VARIABLES
PARAMETER SCALRES2(sc) RESTART SCALAR RESULTS
PARAMETER RSCALE(sc) PERCENT CHANGE FROM BASE SCALARS

for PRICRES

\[ \text{SET rp / PX, PVA, PE, PWE, PM, PAM, PD, P, PROFIT, RENTAL, PINT /} \]

PARAMETER PRICRES1(i,rp) PRICE RESULTS BY SECTOR
PARAMETER PRICRES2(i,rp) RESTART PRICE RESULTS
PARAMETER RPRICE(i,rp) PERCENT CHANGE FROM BASE PRICE RESULTS

for QUANTRES

\[ \text{SET rq / XD, VALADD, SECTORY, E, M, LABOR, CAPITAL, LAND, X, XXD /} \]

PARAMETER QUANTRES1(i,rq) QUANTITY RESULTS BY SECTOR
PARAMETER QUANTRESZ(i,rq)  RESTART QUANTITY RESULTS;
PARAMETER QUANTRES(i,rq)  PERCENT CHANGE FROM BASE QUANTITY RESULTS;

*### SPECIFY TABLES FOR RESTART RATIO SOLUTION REPORTS ###*

PRICRES1(i, "PX") = PX.L(i);
PRICRES1(i, "PVA") = PVA.L(i);
PRICRES1(i, "PE") = PE.L(i);
PRICRES1(i, "PWE") = PWE.L(i);
PRICRES1(i, "PM") = PM.L(i);
PRICRES1(i, "PWM") = PWM(i);
PRICRES1(i, "PD") = PD.L(i);
PRICRES1(i, "P") = P.L(i);
PRICRES1(i, "PROFIT") = PROFIT(i);
PRICRES1(i, "RENTAL") = RENTAL(i);
PRICRES1(i, "PINT") = PINT(i);

QUANTRES1(i, "XD") = XD.L(i);
QUANTRES1(i, "VALADD") = VALADD(i);
QUANTRES1(i, "SECTOR") = SECTOR(i);
QUANTRES1(i, "E") = E.L(i);
QUANTRES1(i, "LABOR") = LABOR(i);
QUANTRES1(i, "CAPITAL") = CAPITAL(i);
QUANTRES1(i, "LAND") = LAND(i);
QUANTRES1(i, "X") = X.L(i);
QUANTRES1(i, "XXD") = XXD.L(i);

SCALRES1("EXR") = EXR.L;
SCALRES1("PINDEX") = PINDEX.L;
SCALRES1("RGNP") = RGNP.L;
SCALRES1("GNPVA") = GNPVA.L;
SCALRES1("INVEST") = INVEST.L;
SCALRES1("FXDINV") = FXDINV.L;
SCALRES1("GDTOT") = GDTOT.L;
SCALRES1("GR") = GR.L;
SCALRES1("SSTAX") = SSTAX.L;
SCALRES1("TARIFF") = TARIFF.L;
SCALRES1("INDTAX") = INDTAX.L;
SCALRES1("ENTTAX") = ENTTAX.L;
SCALRES1("TOTHHTAX") = TOTHHTAX.L;
SCALRES1("NETSUB") = NETSUB.L;
SCALRES1("REMIT") = REMIT.L;
SCALRES1("GENT") = GENT.L;
SCALRES1("HNT") = HNT.L;
SCALRES1("FBOR") = FBOR.L;
SCALRES1("SAVINGS") = SAVINGS.L;
SCALRES1("ENTSAV") = ENTSAV.L;
SCALRES1("DEPRECI") = DEPRECI.L;
SCALRES1("HHSAV") = HHSAV.L;
SCALRES1("GOVSAV") = GOVSAV.L;
SCALRES1("FSAV") = FSAV.L;

SAM("COMMDTY", "ACTIVITY") = SUM(i, (P.L(i)*INT.L(i)));
SAM("COMMDTY", "HOUSEHOLD") = SUM(i, (P.L(i)*CD.L(i)));
SAM("COMMDTY", "KACCOUNT") = SUM(i, (P.L(i)*(DST.L(i)+ID.L(i))));
SAM("COMMDTY", "GOVT") = SUM(i, (P.L(i)*GD.L(i)));
SAM("ACTIVITY", "COMMDTY") = SUM(i, ((EXR.L*PWE.L(i))*E.L(i)));
SAM("ACTIVITY", "COMMDTY") = SUM(i, (PX.L(i)*XD.L(i)) - (PE.L(i)*E.L(i)));

DISPLAY PRICRES1, QUANTRES1, SCALRES1;

*######################################################################## Social Accounting Matrix ###################################
1518 SAM("ACTIVITY","GOVT") = NETSUB.L;
1519 SAM("VALUAD","ACTIVITY") = SUM(f, YFCTR.L(f));
1520 SAM("INSTTNS","VALUAD") = SUM(f,YFCTR.L(f)) - SSTAX.L;
1521 SAM("INSTTNS","GOVT") = GENT.L;
1522 SAM("HOUSEHOLDS","INSTTNS") = SUM(ins,hh),SINTYN(hh,ins)*YINST.L(ins);
1523 SAM("HOUSEHOLDS","GOVT") = HHT.L;
1524 SAM("KACCOUNT","INSTTNS") = ENTSAV.L + DEPRECIA.L;
1525 SAM("KACCOUNT","HOUSEHOLDS") = HHSAV.L;
1526 SAM("KACCOUNT","GOVT") = GOVSAV.L;
1527 SAM("GOVT","commdty") = TARIFF.L;
1528 SAM("GOVT","ACTIVITY") = INDTAX.L;
1529 SAM("GOVT","VALUAD") = SSTAX.L;
1530 SAM("GOVT","INSTTNS") = ENTTAX.L;
1531 SAM("GOVT","HOUSEHOLDS") = TOHTHTAX.L;
1532 SAM("WORLD","COMMDTY") = SUM(i,((PWM(i)*EXR.L)*M.L(i)));
1533 SAM("WORLD","HOUSEHOLDS") = - REMIT.L*EXR.L;
1534 SAM("WORLD","GOVT") = - FBOR.L*EXR.L;
1535 SAM("WORLD","KACCOUNT") = - FSAV.L*EXR.L;
1536 SAM("TOTAL","COMMDTY") = SUM(isam2,SAM(isam2,"COMMDTY"));
1537 SAM("TOTAL","ACTIVITY") = SUM(isam2,SAM(isam2,"ACTIVITY"));
1538 SAM("TOTAL","VALUAD") = SUM(isam2,SAM(isam2,"VALUAD"));
1539 SAM("TOTAL","INSTTNS") = SUM(isam2,SAM(isam2,"INSTTNS"));
1540 SAM("TOTAL","HOUSEHOLDS") = SUM(isam2,SAM(isam2,"HOUSEHOLDS"));
1541 SAM("TOTAL","KACCOUNT") = SUM(isam2,SAM(isam2,"KACCOUNT"));
1542 SAM("TOTAL","GOVT") = SUM(isam2,SAM(isam2,"GOVT"));
1543 SAM("total","WORLD") = SUM(isam2,SAM(isam2,"WORLD"));
1544 SAM(isam3,"TOTAL") = SUM(isam2,SAM(isam3,isam2));
1545
1546 option decimals=3;
1547 DISPLAY SAM;
1548
1549 SETTIME

Compilation time = 10.050 seconds    Ver: 386-EK-008
556 PARAMETER WFDIST  FACTOR PRICE SECTORAL PROPORTIONALITY CONSTANTS

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<td>RESTA</td>
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556 PARAMETER WFO  FACTOR PRICE

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556 PARAMETER FS0  FACTOR SUPPLY

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<td>96.641</td>
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556 PARAMETER YFSECTO  FACTOR INCOME BY SECTOR

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<td>9.807</td>
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556 PARAMETER YFCTRO  FACTOR INCOME SUMMED OVER SECTOR

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557 PARAMETER YINST0  INSTITUTIONAL INCOME

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<tr>
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557 PARAMETER MPS0  HOUSEHOLD MARGINAL PROPENSITY TO SAVE

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557 PARAMETER HTAX  HOUSEHOLD TAX RATE

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571 PARAMETER DELTA  ARMINGTON FUNCTION SHARE PARAMETER
LVSTK  0.233,  EXPCRP  0.177,  OTHCRP  0.366  
AGPROC  0.211,  AGINP  0.042,  INTMNF  0.067  
FDMNF  0.152,  TRDTRN  0.004,  SERVICE 2.580477E-9  

---  571 PARAMETER AC  ARMINTON FUNCTION SHIFT PARAMETER  
LVSTK  1.420,  EXPCRP  1.297,  OTHCRP  1.773,  AGPROC  1.498,  AGINP  1.269  
INTMNF  1.369,  FDMNF  1.563,  TRDTRN  1.022,  SERVICE 1.024,  RESTA 1.000  

---  571 PARAMETER RMD  RATIO OF IMPORTS TO DOMESTIC SALES  
LVSTK  0.008,  EXPCRP  0.002,  OTHCRP  0.111,  AGPROC  0.071,  AGINP  0.096  
INTMNF  0.130,  FDMNF  0.213,  TRDTRN  0.002,  SERVICE 0.019  

---  579 PARAMETER GAMMA  CET FUNCTION SHARE PARAMETER  
LVSTK  1.000,  EXPCRP  0.568,  OTHCRP  0.802,  AGPROC  0.819,  AGINP  0.781  
INTMNF  0.788,  FDMNF  0.778,  TRDTRN  0.818,  SERVICE 0.995,  RESTA 0.998  

---  579 PARAMETER AT  CET FUNCTION SHIFT PARAMETER  
LVSTK  51.023,  EXPCRP  2.076,  OTHCRP  3.006,  AGPROC  3.175  
AGINP  2.823,  INTMNF  2.876,  FDMNF  2.612,  TRDTRN 3.162  
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---  584 PARAMETER ALPHA  FACTOR SHARE PARAMETER-PRODUCTION FUNCTION  

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---  591 PARAMETER AD  PRODUCTION FUNCTION SHIFT PARAMETER  
LVSTK  12.617,  EXPCRP  0.751,  OTHCRP  2.182,  AGPROC 37.138  
AGINP  47.468,  INTMNF 16.892,  FDMNF 48.285,  TRDTRN 18.680  
SERVICE 12.075,  RESTA 0.583  

---  591 PARAMETER QD  DUMMY VARIABLE FOR COMPUTING AD(I)  
LVSTK  6.112,  EXPCRP  95.520,  OTHCRP 12.165,  AGPROC 10.532  
AGINP  5.589,  INTMNF 40.951,  FDMNF 16.933,  TRDTRN 42.026  
SERVICE 216.065,  RESTA 395.827  

---  591 PARAMETER FDO  FACTOR DEMAND  
LABOR  96.641,  CAPITAL 6244.073,  LAND 428.251  

---  597 PARAMETER XO0  DOMESTIC OUTPUT  
LVSTK  77.115,  EXPCRP  71.773,  OTHCRP  26.544,  AGPROC 391.145  
AGINP  265.280,  INTMNF 691.753,  FDMNF 817.594,  TRDTRN 785.067  
SERVICE 2609.047,  RESTA 230.939  

68
597 PARAMETER XO COMPOSITE GOOD SUPPLY
LVSTK  77.557,  EXPCRP  53.983,  OTHCRP  27.809,  AGPROC  399.482
AGINP  269.608,  INTMNF  734.080,  FDMNF  861.036,  TRDTRN  749.789
SERVICE 2549.723,  RESTA  225.490

597 PARAMETER XXDO DOMESTIC SALES
LVSTK  76.904,  EXPCRP  53.866,  OTHCRP  25.026,  AGPROC  372.919
AGINP  245.939,  INTMNF  644.884,  FDMNF  709.591,  TRDTRN  747.944
SERVICE 2501.795,  RESTA  225.490

598 PARAMETER PVAO VALUE ADDED PRICE BY SECTOR
LVSTK  0.127,  EXPCRP  0.409,  OTHCRP  0.573,  AGPROC  0.252,  AGINP  0.129
INTMNF  0.399,  FDMNF  0.392,  TRDTRN  0.557,  SERVICE  0.591,  RESTA  0.686

598 PARAMETER PDO DOMESTIC GOODS PRICE
LVSTK  1.000,  EXPCRP  1.000,  OTHCRP  1.000,  AGPROC  1.000,  AGINP  1.000
INTMNF  1.000,  FDMNF  1.000,  TRDTRN  1.000,  SERVICE  1.000,  RESTA  1.000

598 PARAMETER PEO DOMESTIC PRICE OF EXPORTS
LVSTK  1.000,  EXPCRP  1.000,  OTHCRP  1.000,  AGPROC  1.000,  AGINP  1.000
INTMNF  1.000,  FDMNF  1.000,  TRDTRN  1.000,  SERVICE  1.000,  RESTA  1.000

598 PARAMETER PWM WORLD MARKET PRICE OF IMPORTS (IN DOLLARS)
LVSTK  0.987,  EXPCRP  0.972,  OTHCRP  0.964,  AGPROC  0.897,  AGINP  0.997
INTMNF  0.982,  FDMNF  0.975,  TRDTRN  0.975,  SERVICE  1.000,  RESTA  1.000

598 PARAMETER TM TARIFF RATES ON IMPORTS
LVSTK  0.014,  EXPCRP  0.029,  OTHCRP  0.037
AGPROC  0.115,  AGINP  0.003,  INTMNF  0.018
FDMNF  0.027,  TRDTRN  0.027,  SERVICE 8.345875E-6

598 PARAMETER PWTS PRICE INDEX WEIGHTS
LVSTK  0.013,  EXPCRP  0.012,  OTHCRP  0.004,  AGPROC  0.066,  AGINP  0.044
INTMNF  0.116,  FDMNF  0.137,  TRDTRN  0.132,  SERVICE 0.437,  RESTA  0.039

744 VARIABLE YFCTR.L FACTOR INCOME (BILL $)
LABOR 1907.000,  CAPITAL 977.319,  LAND  22.905

744 VARIABLE YINST.L INSTITUTIONAL INCOME (BILL $)
744 VARIABLE YH.L  HOUSEHOLD INCOME (BILL $)

744 VARIABLE GNPVA.L = 3166.001 VALUE ADDED IN MARKET PRICES GNP (BILL $)

744 VARIABLE RGNP.L = 3166.002 REAL GNP ($)

744 VARIABLE PINDEX.L = 1.000 GNP DEF LATOR

745 VARIABLE INT.L  INTERMEDIATES USES (82 BILL $)

745 VARIABLE CD.L  FINAL DEMAND FOR PRIVATE CONSUMPTION (82 BILL $)

745 VARIABLE GD.L  FINAL DEMAND FOR GOVERNMENT CONSUMPTION (82 BILL $)

745 VARIABLE ID.L  FINAL DEMAND FOR PRODUCTIVE INVESTMENT (82 BILL $)

745 VARIABLE DST.L  INVENTORY INVESTMENT BY SECTOR (82 BILL $)

745 VARIABLE DK.L  VOLUME OF INVESTMENT BY SECTOR OF DESTINATION (82 BILL $)
### 789 PARAMETER SAM

#### SOCIAL ACCOUNTING MATRIX

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MODEL STATISTICS

BLOCKS OF EQUATIONS 45
BLOCKS OF VARIABLES 50
NON ZERO ELEMENTS 1321
DERIVATIVE POOL 23
CODE LENGTH 7354

GENERATION TIME = 14.550 SECONDS

EXECUTION TIME = 23.460 SECONDS

SOLVE SUMMARY

MODEL US82
TYPE NLP
SOLVER MINOS5

**** SOLVER STATUS 1 NORMAL COMPLETION
**** MODEL STATUS 2 LOCALLY OPTIMAL
**** OBJECTIVE VALUE 3166.0009

RESOURCE USAGE, LIMIT 39.0000 1000.0000
ITERATION COUNT, LIMIT 195 1000
EVALUATION ERRORS 0 0

MINOS 5.2 (Jun 1989)
B. A. Murtagh, University of New South Wales
and
P. E. Gill, W. Murray, M. A. Saunders and M. H. Wright
Systems Optimization Laboratory, Stanford University.

WORK SPACE NEEDED (ESTIMATE) -- 21910 WORDS.
WORK SPACE ALLOCATED -- 39052 WORDS.

EXIT -- OPTIMAL SOLUTION FOUND
MAJOR ITNS, LIMIT 8 50
FUMOBJ, FUCON CALLS 0 13
SUPERBASICS 0
INTERPRETER USAGE 0.00
NORM RG / NORM PI 0.0000E+00

**** REPORT SUMMARY : 0 NONOPT
0 INFEASIBLE
0 UNBOUNDED
0 ERRORS
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### 1138 Parameter: FCTRES1

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### 1138 Parameter: FCTRES2

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### 1138 Parameter: SECTRES

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LABR  ENT  PROP

YINST 1637.464178  558.575138  22.905524

--- 1138 PARAMETER HHRES  MISCELLANEOUS HOUSEHOLD RESULTS

HHTRN  HHLAB  HHCAP

MPS  0.061607  0.174295
YH  396.249995  1637.464178  580.230662

--- 1251 PARAMETER AGTOTFD  =  100.000 AGRICULTURAL TERMS OF TRADE
PARAMETER AGTOTVA  =  62.939 AG TERMS OF TRADE VALUE
PARAMETER AGTOTM  =  99.345 AG TERMS OF TRADE WORLD
PARAMETER AGTOTTE  =  100.000 AG TERMS OF TRADE WORLD

--- 1275 PARAMETER BOT  =  26.300 NOMINAL BALANCE OF TRADE
PARAMETER BOTR  =  17.700 REAL BALANCE OF TRADE
PARAMETER NEX  =  361.900 NOMINAL EXPORTS
PARAMETER ESUM  =  361.900 REAL EXPORTS
PARAMETER NIM  =  335.600 NOMINAL IMPORTS
PARAMETER MSUM  =  344.200 REAL IMPORTS
PARAMETER SHCONSUMP  =  64.773 CONSUMPTION SHARE OF
PARAMETER SHINVEST  =  14.128 INVESTMENT SHARE OF
PARAMETER SHGDTOT  =  20.268 GOVT CONSUMPTION SHARE OF
PARAMETER SHGEX  =  11.431 EXPORT SHARE OF NOMINAL GNP
PARAMETER SHIM  =  10.600 IMPORT SHARE OF NOMINAL GNP
PARAMETER SHBOT  =  0.831 BALANCE OF TRADE SHARE OF
PARAMETER SHFSAV  =  0.230 FOREIGN SAVING SHARE OF
PARAMETER SHGSAV  =  -24.778 GOVERNMENT SAVING SHARE OF
PARAMETER SHPSAV  =  124.548 PRIVATE SAVING SHARE OF

--- 1297 PARAMETER COLIND  =  100.000 COST OF LIVING INDEX
PARAMETER EXRIND  =  100.000 REAL EXCHANGE RATE INDEX
PARAMETER NGNP  =  3166.000 NOMINAL GNP
PARAMETER PDIND  =  100.000 DOMESTIC SUPPLY PRICE INDEX
PARAMETER PIND  =  100.000 COMPOSITE GOOD PRICE INDEX

74
PARAMETER PEIND = 100.000  DOMESTIC EXPORT PRICE INDEX
PARAMETER PMIND = 100.000  DOMESTIC IMPORT PRICE INDEX
PARAMETER PWEIND = 100.000  WORLD EXPORT PRICE INDEX
PARAMETER PWMIND = 97.501  WORLD IMPORT PRICE INDEX
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75
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