An Application
of the Computable General Equilibrium
Model to Analyze U.S. Agriculture

Satheesh V. Aradhyula, K. Eswaramoorthy, and Klaus Frohberg

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Abstract

The effects of exchange rate and capital stock changes are
analyzed using a CGE model for the United States. The model is
in the Walrasian tradition and is calibrated to 1982 data.
Results indicate that a devaluation of the U.S. dollar has a
positive effect on the agricultural sector and balance of
trade, but has a negative effect on consumers.

Introduction

The importance to the agricultural sector of exchange rates and other instruments of monetary and fiscal policies was first emphasized by Schuh (1974). His seminal work sparked other studies of the interaction between agricultural production and incomes and traditional instruments of macroeconomic policy. Integrated sectorial and macroeconomic models to study the impact of interest and exchange rates on U.S. agriculture have been formulated by Shei (1978), Hughes and Penson (1980), and Chambers and Just (1982). These studies are mostly empirical and are not "complete" general equilibrium models. They fail to recognize the full circular flow of income and goods in the economy.

This study presents a computable general equilibrium (CGE) model for the U.S. economy with emphasis on the agricultural sector. The model is in the tradition of Walrasian price endogenous models, generating equilibrium solutions for both quantities and prices. The model is based on a social accounting matrix (SAM) information system. The model is static and is calibrated for the base year 1982. The estimated model is then used to carry out two counterfactual experiments to analyze the impact of exchange rate and capital stock shocks on agriculture.

A SAM for the United States

As a data framework the SAM provides a "snapshot" of the economy and describes the full circular flow of money and goods. In the SAM, the rows and columns represent the receipt and expenditure accounts, of economic actors. Thus, the SAM is a square matrix whose row and column sums must balance. Such a SAM is constructed for the United States for the year 1982 (Table 1) by modifying national income and product accounts data and using other relevant data and information. For a discussion on the construction of a SAM, see Pyatt and Round

Table 1. SAM for the United States, 1982

Account	Activities			Factors		Institutions				
	Agri. 1	Agri. Related 2	Other 3	Labor Income 4	Capital Income 5	Enter-prises 6	Households 7	Capital Account 8	Govt. 9	Rest of World 10
						billion $				
Activities										
Agriculture	49.91	93.81	9.81				20.42	-0.22	8.28	19.41
Ag. related act.	70.63	1119.77	442.84				1714.43	40.55	451.88	97.33
Other activities	7.97	452.87	644.77				250.04	374.53	190.32	231.68
Factors										
Labor income	18.79	1314.26	531.17							
Capital income	45.13	701.08	200.06							
Institutions										
Enterprises					834.77				53.25	
Households				1612.96	111.51	439.30			361.92	-1.17
Capital account						388.05	135.50		-115.24	6.55
Government	3.64	217.21	37.92	251.31		60.66	404.08		179.51	-24.42
Rest of the world	5.35	38.42	285.63							
Totals	201.43	3937.42	2152.19	1864.22	946.27	888.01	2120.39	414.86	1129.91	329.40

Note: This SAM is, in principle, the same as the one constructed by Adelman and Robinson (1986). The agricultural related sector in the SAM includes food processing, wholesale retail trade, utilities, banking, chemicals, and services.

(1985). Table 1 reveals that about 75 percent of total agricultural expenditures are for purchases of nonagricultural inputs. The table suggests that there are significant linkages between the agricultural sector and the rest of the economy.

Assumptions and Structure of the Model

Closure Rule 1

Closure Rule 1 has three production sectors, an agricultural sector, an agricultural related sector, and an aggregate "other" production sector. Other endogenous accounts include two primary factors, labor and capital, plus a household sector, an investment sector, a government sector, and a rest of the world sector. See Appendices A and B for a complete list of equations and variable definitions.

Production in each sector is described by a two-level, fixed coefficient, value-added production system:

$$X_i = \min\{V_i/a_{vi}, \ X_{ij}/a_{ij} \ \ j = 1,2,3\} \quad i = 1,2,3 \qquad (1)$$

where X_i is the gross output of industry i; V_i is the value added in industry i; a_{vi} is the value added requirement per unit of output i; X_{ij} is the use of good j in industry i, and a_{ij} is the requirement of good j per unit of good i. Substitution between the primary factors of labor and capital is allowed in meeting each industry's value-added requirements through the CES function

$$V_i = b_i [d_i L_i^{1-1/\sigma_i} + (1 - d_i) K_i^{1-1/\sigma_i}]^{\sigma_i/(\sigma_i - 1)}$$

$$i = 1,2,3 \qquad (2)$$

where L_i is the amount of labor used in industry i; K_i is the amount of capital used in industry i; and b_i, d_i, and σ_i are parameters. Indirect taxes are levied as a fixed proportion of gross revenue. Profit maximization is assumed in all three

production sectors and input demand functions are derived
accordingly. The economy has fixed amounts of resources and
full use of these factors is assumed. Since factor prices are
the same across all sectors, it is ensured that the marginal
value product of a factor is the same in all sectors.

Labor income is transferred to households, the owners of
factors, after paying a fixed percentage of factor tax.
Capital income is transferred to households and enterprises. A
portion of enterprises income is invested. After paying a
constant proportion of capital income tax, the rest is
distributed among households. Labor income, capital income,
and enterprise income, together with some government transfer
minus net remittances to the rest of the world, form the total
gross income of households. Households have a fixed rate of
savings and income tax. Disposable income for households is
obtained by subtracting the savings and income tax from their
gross income. Households maximize their utility subject to
this level of disposable income. The total household
consumption expenditure is allocated to the three goods as a
linear expenditure system.

Government revenue consists of indirect business taxes,
factor taxes, corporate taxes and net foreign reserve
accumulations. Government expenditures include final
consumption expenditures on the three goods, plus transfers to
households and corporations. The government budget surplus is
endogenously determined as the difference between government
revenues and expenditures. Savings come from households,
enterprises, foreign capital inflow, and government and equal
total investment in the economy. Investments are divided into
three sectors based on endogenously determined shares.

To determine exports and imports, simple export demand and
import supply functions are used under this closure rule. It
is assumed that world export demands and import supplies depend
only on own prices and are of the constant elasticity form:

$$E_i = e_i (P_i/\bar{x})^{\eta_i} \qquad i = 1,2,3 \quad -\infty < \eta \leq 0 \qquad (3)$$

$$M_i = m_i \{P_i(1 - \bar{t_i})/\bar{x}\}^{\gamma_i} \qquad i = 1,2,3 \quad \infty > \gamma_i \geq \qquad (4)$$

where E_i is exports of good i; M_i is imports of good i;
P_i is domestic price of good i; $\bar{x}$ is the exchange rate; and t_i
is the tariff rate. Therefore, $P_i/\bar{x}$ and $p_i(1 - t_i)/\bar{x}$ are the
world prices of exports and imports respectively. Further,
η_i and γ_i are restricted to be finite since infinite
elasticities would exogenously fix domestic prices. Thus, the
economy considered here cannot technically be a "small open"
one.

Balance of trade is endogenously determined as the
difference between value of exports and imports. Finally,
system constraints are imposed so that supply equals demand in
each market. Thus, the excess demand functions in each market
are set to equal zero and are solved for prices. Since the
model is Walrasian, only relative prices matter. The price of
agricultural related goods is taken as the numéraire.

Alternative Closure Rule

The model is not completely satisfactory for several
reasons. In the data, 1982 SAM for the United States, all
three products are both exported and imported at the same time.
But the specification in (4) treats imports of a product as a
perfect substitute for a domestically produced product. At the
same time, the world price of exports of product i $(P_i/\bar{x})$ may
differ from the world price of imports $P_i(1 - t_i)/\bar{x}$ because of
tariffs. Therefore, the perfect substitutability between
domestically produced products and imported products is assumed
to hold in the United States cannot hold abroad. In other
words, cross-hauling of the products is not explained
adequately because of the aggregate nature of the industry data
that is used. To overcome this problem, an alternate closure
rule is examined in which imports are treated as imperfect
substitutes for domestic products. Imports are substitutable
for domestic products in both final demand and intermediate
use. The representation of the substitutability is achieved by
defining a new commodity (Q_i), which is a composite of
domestically produced goods (X_i) and imports (M_i) where the
composite is a CES-type function. This is the Armington

approach, where goods of both foreign and domestic origin are brought together to form a composite bundle that is used to meet domestic demand. Imports are specified as derived demand and take the form:

$$M_i = m_i \ \{P_i^C/(\bar{P}_i \bar{x}(1 + t_i))\}^{\mu_i} Q_i \qquad (5)$$

where P_i^C is the price of composite good i; $\bar{P}_i$ is the world price of good i, and assumed to be fixed; μ_i is the elasticity of substitution between domestically produced goods and imported goods in Sector i; and m_i is a scaling parameter. The United States is a small open economy in import markets, though not in export markets. The other equations in this closure rule are the same as in the earlier case except that demanders of goods now pay the composite good price rather than domestic (producer) price. Also, the price of composite goods is determined so that the demand for the composite good equals the supply. Throughout the rest of this discussion this treatment of imports is referred to as closure rule 2.

Calibration and Parameter Estimation

The calibration procedure outlined in Mansur and Whalley (1984) has been followed to estimate the parameter values. However, a few of the model's parameters cannot be estimated from the base year SAM listed in Table 1. These are elasticities of factor substitution (σ_i), price elasticities of exports (η_i), price elasticity of imports (τ_i) (for closure rule 1), and elasticity of substitution between imports and domestically produced goods (μ_i) (for closure rule 2). These parameters are exogenously specified (see Table 2) based on previous empirical literature (Berndt 1973, Ray 1982, Meyers 1986, Gardiner 1987). Alternatively, all the parameters can, in principle, be estimated simultaneously if suitable time series data are available. The gain in efficiency may or may not be worth the extra effort involved. The model is calibrated separately under the two closure rules to exactly

Table 2. Exogenously specified elasticities in the model

Elasticity	Value
Elasticity of factor substitution	
Agriculture sector (σ_1)	0.50
Ag. related sector (σ_2)	0.50
Other sector (σ_3)	0.50
Price elasticity of exports	
Agriculture sector (η_1)	-0.30,-0.50,-0.80
Ag. related sector (η_2)	-0.30
Other sector (η_3)	-0.30
Closure rule 1:	
Price elasticity of imports	
Agriculture sector (γ_1)	0.50
Ag. related sector (γ_2)	0.50
Other sector (γ_3)	0.50
Closure rule 2:	
Elasticity of substitution between imports and domestic goods (in the closure rule 2)	
Agriculture sector (μ_1)	2.00
Ag. related sector (μ_2)	2.00
Other sector (μ_3)	2.00

reproduce the base case as set out in the initial SAM. This
guarantees that at least in one case the model has a solution.
Counterfactual equilibrium situations can be compared to this
base.

Since some parameters are specified exogenously, the
sensitivity of endogenous variables to changes in these
parameters is examined. Values of exogenously imposed
parameters are changed, one at a time, and changes in the
endogenous variables are computed. In a total of more than 50
such cases, more than four-fifths of elasticities of endogenous
variables to exogenously specified parameters were less than
0.1 in absolute value. The results obtained with this model
can thus be considered robust to large changes in the exogenous
parameters.

Results

Results are reported on the impact of changes in the value
of the U.S. dollar and the capital stock on U.S. agriculture
and the economy in general. The experiments we chose are a 10
percent decrease in U.S. dollar value and a 10 percent increase
in capital stock. In both these experiments the model is
solved for quantities and prices after exogenously injecting
the shock. The analysis is carried out under both closure
rules 1 and 2, enabling us to examine the sensitivity of
results to the specifications of the closure rules. Results
under some parameter changes to which endogenous variables are
sensitive are also presented.

Results of the two experiments under closure rule 1 are
summarized in Table 3. Table 4 presents the results of the
same experiments under closure rule 2. There are more than one
hundred endogenous variables in the model, so discussion is
limited to the more interesting variables.

The results presented in Table 3 indicate, as expected,
that a devaluation of the U.S. dollar increases exports and
decreases imports in all three sectors. Consequently, the
balance of trade improves considerably. Balance of trade is
more sensitive to exchange rate fluctuations than quantity

Table 3. Results of the experiments under closure rule 1

Variable	1982 Value in 1982 Bil. dollars	Experiment 1. 10% Decrease in U.S. $ Value. % Change from base			Experiment 2. 10% Increase in Capital Stock % Change from base
		$\eta_1=-0.30$	$\eta_1=-0.50$	$\eta_1=-0.80$	$\eta_1=-0.50$
Production:					
Agriculture	196.07	0.14	0.26	0.64	3.94
Ag. related	3899.01	-0.54	-0.55	-0.56	4.47
Other	1866.55	1.48	1.49	1.49	-0.49
Exports:					
Agriculture	19.41	2.86	4.82	7.83	-4.65
Ag. related	97.33	2.85	2.85	2.86	-3.67
Other	231.68	2.85	2.85	2.85	-3.90
Imports:					
Agriculture	5.35	-4.59	-4.60	-4.60	4.88
Ag. related	38.43	-4.57	-4.58	-4.59	6.43
Other	285.63	-4.57	-4.57	-4.58	6.85
Labor Use:					
Agriculture	18.79	-0.08	0.18	0.78	-2.63
Ag. related	1314.26	-0.58	-0.59	-0.60	1.22
Other	531.17	1.44	1.45	1.46	-2.92
Capital Use:					
Agriculture	45.13	0.05	0.30	0.68	6.94
Ag. related	701.08	-0.45	-0.47	-0.49	11.16
Other	200.06	1.58	1.58	1.57	6.61
Capital Labor Ratio:					
Agriculture	2.40	0.13	0.12	0.11	9.83
Ag. related	0.53	0.13	0.12	0.11	9.83
Other	0.38	0.13	0.12	0.11	9.83
Money Metric	1984.89	-0.61	-0.62	-0.64	5.06
Balance of trade	19.02	131.60	133.74	137.04	-206.20
GNP	3069.25	0.15	0.14	0.12	17.09
Prices (1982=1.00)					
Agriculture	1.00	-0.04	-0.04	-0.04	-2.89
Other	1.00	0.01	0.01	0.01	0.79
Labor	1.00	0.09	0.08	0.07	6.48
Capital	1.00	-0.17	-0.16	-0.14	-11.72

Notes: η_1 is the price elasticity of agricultural exports. All prices are relative prices, relative to the price of agricultural related good. GNP and Balance of trade are measured in current dollars. All other variables are measured in 1982 dollars.

Table 4. Results of the experiments under closure rule 2

Variable	1982 Value in 1982 Bil. dollars	Experiment 1. 10% Decrease in U.S. $ Value. % Change from base			Experiment 2. 10% Increase in Capital Stock % Change from base
		η_1=-0.30	η_1=-0.50	η_1=-0.60	η_1=-0.50
Production:					
Agriculture	196.07	0.37	0.61	0.98	3.55
Ag. related	3899.01	-0.60	-0.61	-0.62	4.70
Other	1866.55	2.96	2.97	2.98	-3.02
Exports:					
Agriculture	19.41	2.77	4.67	7.59	-4.43
Ag. related	97.33	2.76	2.76	2.76	-3.52
Other	231.68	2.79	2.80	2.80	-3.81
Imports:					
Agriculture	5.35	-16.59	-16.55	-16.50	25.16
Ag. related	38.43	-17.14	-17.17	-17.21	33.25
Other	285.63	-14.29	-14.31	-14.33	25.82
Labor Use:					
Agriculture	18.79	0.06	0.31	0.68	-2.73
Ag. related	1314.26	-0.70	-0.70	-0.71	1.54
Other	531.17	1.72	1.72	1.74	-3.70
Capital Use:					
Agriculture	45.13	0.21	0.45	0.81	6.76
Ag. related	701.08	-0.55	-0.56	-0.59	11.44
Other	200.06	1.87	1.87	1.87	5.69
Capital Labor Ratio:					
Agriculture	2.40	0.15	0.14	0.13	9.75
Ag. related	0.53	0.15	0.14	0.13	9.75
Other	0.38	0.15	0.14	0.13	9.75
Money Metric	1984.89	-1.00	-1.01	-1.03	5.82
Balance of trade	19.02	164.40	166.48	169.67	-297.00
GNP	3069.25	0.21	0.20	0.19	16.93
Prices (1982=1.00)					
Agriculture	1.00	-0.06	-0.06	-0.06	-2.86
Other	1.00	-0.12	-0.12	-0.13	1.01
Labor	1.00	-0.17	-0.18	-0.19	6.88
Capital	1.00	-0.47	-0.46	-0.45	-12.70
Prices-Composite Good:					
Agriculture	1.00	0.20	0.20	0.20	-3.13
Ag. related	1.00	0.09	0.09	0.09	-0.13
Other	1.00	1.20	1.20	1.20	-1.03

Notes: η_1 is the price elasticity of agricultural exports. All prices are relative prices, relative to the price of agricultural related good. GNP and Balance of trade are measured in current dollars. All other variables are measured in 1982 dollars.

changes because of a price effect enforcing the quantity
changes. On the production side, the agriculture sector as
well as the other sectors expand, whereas output of the
agricultural related total labor and total capital in the
economy are fixed, at least one sector has to contract when
another expands. The agricultural sector expands to benefit
from a devaluation of the U.S. dollar. Wage rate rises
relative to the price of capital and all sectors become more
capital intensive. It may be noted here that the capital labor
ratio rises in all sectors by the same percentage points. This
is because, by assumption, the elasticity of substitution
between capital and labor is the same in all three sectors.
GNP of the economy goes up slightly.

However, on the demand side, consumers are hurt because of
an increase in the general price level and a decrease in
personal income. This is evident by a decrease in the
money-metric.[2] Personal income goes down because the trade
surplus increases more than does value added after taxes; i.e.,
the economy is saving more money (to be lent abroad) instead of
making it available for current domestic consumption. The
benefits from this savings cannot be measured in a static model
like this one.

The results seem to be qualitatively invariant to changes
in the export demand elasticity. However, some endogenous
variables such as exports, imports, and balance of trade seem
to be more sensitive to exchange rate fluctuations when export
elasticities are larger in absolute value.

Qualitatively, results are quite similar under closure
rule 2 (see Table 4) except that variables are more sensitive.
The higher responsiveness of trade variables can be attributed
to the fact that closure rule 2 leads to adjustment in the
composition of consumption goods. Because of a decrease in
world prices relative to domestic prices, the share of imports
in composite goods increases. Adjustments in production to
exchange rate changes are stronger under closure rule 2 than
under closure rule 1. Prices are also considerably more
sensitive under closure rule 2. Agricultural prices increase
relative to the other sector but still decline in comparison to
the agricultural related sector. These results are different

from those under closure rule 1 and may be attributed to the
changes in consumer preference toward cheaper imports. In
general, results are consistent with results in exchange rate
literature (Shei 1978).

When the total capital stock in the economy is increased,
relatively capital intensive agriculture and agriculture
related sectors benefit. Production in both these sectors
increases, whereas the production of the other sector
decreases. As expected, all sectors become more capital
intensive because of cheaper capital. Because of increased
factor supply, personal income increases, leading to a higher
demand for imported goods. As a result, imports increase and
balance of trade worsens. As in the previous experiment, the
results are qualitatively similar under both closures.

Summary

A simple computable general equilibrium model based on a
social accounting matrix has been presented. The model is
developed on the basis of theoretically plausible
specifications, incorporating a wide range of interaction
effects. The model allows for substitution possibilities in
production and consumption and is capable of addressing a wide
array of policy questions. The model is calibrated to 1982
data under two different specifications of closure rules. Two
policy experiments are carried out by shocking the exchange
rate and capital stock. Results indicate that there are
significant linkages between the agricultural sector and the
rest of the economy. Specifically, a devaluation of the U.S.
dollar seems to have a positive effect on the agricultural
sector and balance of trade while hurting consumers. This and
other general qualitative results are found to be robust under
differing assumptions about elasticities of world demand for
exports. When the capital stock is increased, more
capital-intensive agriculture and agriculture related sectors
benefit the most.

A number of refinements can easily be made in the model.
An obvious extension would be to incorporate a higher degree of

sectorial disaggregation and to introduce dynamics. Dynamics
is especially important because some policy changes take more
than one period to impact fully on the economy. Labor may also
be divided into skilled and unskilled, the factor supply can be
endogenized, and the full employment assumption can be relaxed.
A more interesting extension would be to introduce
uncertainty.

Appendix A
Closure Rule 1 Equations and Variables

Included here are the model equations and variable definitions under closure rule 1. A bar on a variable indicates that it is exogenous. Lowercase letters are parameters that can be estimated from the base year SAM. Greek letters indicate exogenously specified parameters. In general, i and j subscripts refer to production sectors and h subscript refers to households. Superscripts i and e refer to income and expenditure.

Production and Factor Use

$$(A.1) \qquad X_{ij} = a_{ij} X_j \qquad\qquad\qquad i = 1,2,3 \; j = 1,2,3$$

$$(A.2) \qquad V_i = a_{vi} X_i \qquad\qquad\qquad\qquad i = 1,2,3$$

$$(A.3) \qquad L_i = l_i (P_i/w)^{\sigma_i} X_i \qquad\qquad\qquad i = 1,2,3$$

$$(A.4) \qquad K_i = k_i (P_i/r)^{\sigma_i} X_i \qquad\qquad\qquad i = 1,2,3$$

$$(A.5) \qquad T_{ib} = t_{ib} \cdot P_i X_i \qquad\qquad\qquad i = 1,2,3$$

$$(A.6) \qquad \sum_{j=1}^{3} P_i X_{ji} + wL_i + rK_i + T_{ib} = P_i X_i \qquad i = 1,2,3$$

$$(A.7) \qquad \sum_{i=1}^{3} K_i = \bar{K}$$

$$(A.8) \qquad \sum_{i=1}^{3} L_i = \bar{L}$$

Income and Investment

$$(A.9) \qquad L_y = \sum_{i=1}^{3} w \, L_i$$

$$(A.10) \qquad T_\ell = t_\ell \, L_y$$

(A.11) $L_{hy} = \ell_h \, L_y$

(A.12) $T_\ell + L_{hy} = L_y$

(A.13) $K_y = \sum_{i=1} r \, K_i$

(A.14) $K_{ey} = k_e \cdot K_y$

(A.15) $K_{hy} = k_h \cdot K_y$

(A.16) $K_{ey} + K_{hy} = K_y$

(A.17) $N^i = K_{ey} + G_e$

(A.18) $N_h = n_h \, N^e$

(A.19) $T_c = t_c \, N^e$

(A.20) $N_s = n_s \, N^e$

(A.21) $N_h + T_c + N_s = N^e$

(A.22) $N^i = N^e$

(A.23) $S = N_s + S_h + G_s + R_s$

(A.24) $I_i = i_i \, I$ $i = 1,2,3$

(A.25) $I = \sum_{i=1}^{3} I_i$

(A.26) $S = I$

Household Income and Consumption

(A.27) $Y_h^i = L_{hy} + K_{hy} + G_h - R_h$

(A.28) $T_h = t_h \cdot Y_h^e$

(A.29) $S_h = s(\, Y_h^e - T_h)$

(A.30) $C_{ih} = c_{ih} \cdot (Y_h^e - T_h - S_h)/P_i$ $i = 1,2,3$

(A.31) $Y_h^e = T_h + S_h + \sum_{i=1}^{3} P_i C_{ih}$

(A.32) $Y_h^e = Y_h^i$

Government Revenue and Expenses

(A.33) $G^i = \sum_{i=1}^{3} T_{ib} + T_\ell + T_c + T_h + R_g$

(A.34) $C_{ig} = c_{ig} \, G^e / P_i$ $\qquad\qquad\qquad\qquad i = 1,2,3$

(A.35) $G_e = g_e \, G^e$

(A.36) $G_h = g_h \, G^e$

(A.37) $G^e = \sum_{i=1}^{3} C_{ig} + G_e + G_h$

(A.38) $G_s = G^i - G^e$

Foreign Trade

(A.39) $M_i = m_i \, P_i^{\gamma_i} \, \bar{x}^{-\gamma_i} \quad \gamma_i > 0$ $\qquad\qquad i = 1,2,3$

(A.40) $E_i = e_i \, P_i^{\eta_i} \, \bar{x}^{-\eta_i} \quad \eta_i < 0$ $\qquad\qquad i = 1,2,3$

(A.41) $R_h = r_h \, R$

(A.42) $R_s = r_s \, R$

(A.43) $R_g - r_g \, R$

(A.44) $R = \sum_{i=1}^{3} P_i E_i - R_h + R_s + R_g$

(A.45) $P_i X_i = \sum_{j=i}^{3} P_i X_{ij} + P_i C_{ih} + I_i + P_i C_{ig} + P_i E_i - P_i M_i \, i =$

(A.46) $B = \sum_{i=1}^{3} P_i E_i - \sum_{i=1}^{3} \{P_i \, (1-t_i)/\bar{x}_i\} \, M_i$

Endogenous Variables

B	Balance of trade
C_{ig}	Government final consumption demand for good i
C_{ih}	Household consumption demand for good i
E_i	Exports of good i
G_e	Government transfers to enterprises
G_h	Government transfers to households
G_s	Government surplus
G^e	Total government expenses
G^i	Total government revenue
I	Total investment
I_i	Investment in the ith sector
K_i	Capital used in the ith sector
K_{ey}	Capital income accrued to enterprises
K_{hy}	Capital income accrued to households
K_y	Total capital income
L_i	Labor used in the ith sector
L_{hy}	Labor income accrued to households
L_y	Total labor income
M_i	Imports of ith good
N_h	Corporate profits distributed to households
N_s	Retained (saved) corporate profits
N^e	Total enterprise expenditure
N^i	Total enterprise income
P_i	Domestic price of good i
r	Price of capital
R	Total foreign exchange accumulation
R_g	Total government reserve decumalation
R_h	Net foreign remittances of household
R_s	Net capital inflow from the rest of the world
S	Total savings of the economy
S_h	Saving of households

T_c	Corporate taxes
T_{ib}	Indirected business tablespaid by i^{th} sector
T_h	Income tax paid by households
T_ℓ	Factor taxes paid by labor sector
V_i	Value added by sector i
w	Wage rate
X_i	Total gross output of sector i
X_{ij}	Amount of good i used in the sector j
Y_h^e	Total expenditure of households
Y_h^i	Total income of households

Exogenous Variables

$\bar{K}$	Total capital stock in the economy
$\bar{L}$	Total labor hours available in the economy
$\bar{x}$	Exchange rate, \$/SDR

Appendix B
Closure Rule 2 Equations and Variables

Equations for the model under closure rule 2 that differ from that in closure rule 1 (Appendix A) are presented here. The model under closure rule 2 has equations (A.1)-(A.5), (B.6), (A.7)-(A.29), (B.30), (B.31), (A.32), (A.33), (B.34), (A.35)-(A.38), (B.39), (A.40)-(A.44), (B.45), (A.46), (B.47), and (B.48).

(B.6) $\quad \sum_{j=1}^{3} P_i^C X_{ji} + wL_i + rK_i + T_{ib} = P_i X_i \qquad i = 1,2,3$

(B.30) $\quad C_{in} = c_{ih}(Y_n^e - T_n - S_h)/P_i^C \qquad\qquad i = 1$

(B.31) $\quad Y_h^e = T_h + S_h + \sum_{i=1}^{3} P_i^C C_{ih}$

(B.34) $\quad C_{iq} = C_{ig} \cdot G^e/P_i^C \qquad\qquad\qquad i = 1,2,3$

(B.39) $\quad M_i = m_i\{P_i^C/[\bar{P}_i\bar{x}(1 + t_i)]\}^{\mu_i} Q_i \;\; \mu_i > 0 \quad i = 1,2,3$

(B.45) $\quad X_i = D_i + E_i \qquad\qquad\qquad\qquad i = 1,2,3$

(B.47) $\quad D_i = (1 - m_i)\{P_i^C/P_i\}^{\mu_i} Q_i \;\; \mu_i > 0 \qquad i = 1,2,3$

(B.48) $\quad P_i^C Q_i = P_i D_i + \{\bar{P}_i\bar{x}(1 + t_i)\}M_i$

Endogenous Variables

PD_i Domestic supply for the final demanded
P_i^C Price of ith composite good
Q_i Quantity of composite good demanded/supplied

Exogenous Variables

$\bar{P}_i$ World price of ith good

Endnotes

1. While this model treats the U.S. economy as a general
    equilibrium system, it is linked to the rest of the world
    according to the partial equilibrium functions (3) and (4).
    To do otherwise would require constructing a general
    equilibrium model for the entire world.

2. Money-metric is a consumer welfare index. It is equal to
    the equivalent variation plus base period's expenditure.
    In the case of the LES demand system we use, it is given
    by

$$\text{Money-Metric} = \prod_{i=1}^{3} (P_{i0}/P_{i1})^{c_{ih}} (Y_h - T_h)$$

where P_{i0} = Price of good i in the base solution, and P_{i1} =
price of good i in the "after-shock" solution. Under
closure rule 2, respective composite good prices should be
used instead. For further details, see McKenzie (1983).

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