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CGE Model and Its Micro and Macro Closures *

by

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1. Introduction and purpose

CGE or "computable general equilibrium" model has now a fairly long history of development since the Johansen's multisectoral growth model of 1960 for Norway. The Johansen's model was succeeded by the ORANI model of the Australian economy, which became the basis of the GTAP model with global linkage for the world economy. Another line of development is the Harberger-Scarf-Shoven-Whalley approach with the firm basis on the Herbert Scarf's computer algorithm for numerical solution. It was called AGE or "applied general equilibrium" model and applied mainly to US and other developed economies. The third line of development is the CGE model for developing countries, which originated from the Adelman-Robinson model of income distribution in Korea to be succeeded by the World Bank for the analysis of development planning and policies. CGE model is now the common name to denote numerical models of general equilibrium type, covering ORANI, AGE and almost all others. It is now widely used for the analysis of trade, taxation, income distribution, structural adjustment, industrial policy, environmental problems and so on, both in developed and developing countries.[1]

There exist no big, essential differences in the framework and structure of CGE models between developed and developing countries, provided that they are the models of neoclassical type which permit basically the working and effectiveness of the markets. Differences, however, may become essential within the developing CGE models when the models of neoclassical type, which trust markets basically, are contrasted with those of structuralist, which emphasize structural rigidities in markets and institutions specific to developing countries. Major differences between the two are found in the treatment of market equilibrium (i.e., closures of CGE model), the specification of behavioral equations (especially for producers), and so on. As extensions of the neoclassical CGE model, Robinson (1989) discusses clearly in detail three different types: an elasticity structuralist CGE model, micro structuralist models, and macro structuralist models. All the three have the problem of closures at the core, i.e., how to treat equilibrium of micro level in each market as well as saving-investment equality of

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[1] See Bergman (1990), Dixon and Parmeter (1996), Robinson (1989), Dervis, de Melo and Robinson (1982), etc. There are some other lines of development, of which the econometric approaches to CGE modeling such as the Hudson-Jorgenson model are the least vulnerable to the criticism made from the empirical validation.

macro level in the national economy, which is relevant and essential also to the CGE models of developed countries.

The purpose of this paper is to discuss the problem of micro and macro closures in the light of Robinson (1989) further, focusing narrowly on the Walras' Law of the neoclassical CGE model and its extensions, and to show some new aspects of closures in practical use and construction of CGE models for developed and developing countries. Standard CGE models such as Lofgren, Harris and Robinson (2002) are now available for practical CGE applications, and Lofgren (2003a) provides a model of the simplest version of the prototype economy as exercises using GAMS, the framework of which is used for our discussion of closures without losing any generality in outcome.

2. SAM for a CGE model: data, specification and Walras' Law

Table 1 shows data of a prototype economy using the framework of SAM (social accounting matrix), which is from Lofgren (2003a, Table 6). The SAM is broken down to the necessary minimum in sectors, factors and institutions to summarize and represent the actual economy. This representative economy consists of two aggregate sectors: agriculture (AGR) and non-agriculture (NAGR), in connection with which activities (A), commodities (C) and composite goods (Q) are defined. The economy has two factors: labor (LAB) and capital (CAP), and three institutional sectors: households (HHD), government (GOV) and the rest of the world (ROW). Households are of two kinds: urban (U) and rural (R). Government levies three kinds of taxes: income tax (YTAX), sales tax (STAX) and tariffs and export duties (TAR). Saving comes from households (or the private sector), government, and the rest of the world to be used for investment (S-I). The SAM of Table 1 represents well the actual economy, though corporations as producers are integrated with activities while those as savers with households. It is needless to say that row sums must be equal to the corresponding column sums in SAM. It is crucial in CGE modeling to give proper economic meanings to these equalities.

Table 2 is the SAM for a CGE model, which corresponds exactly to the data of Table 1. Each of the non-empty cells in Table 1 is expressed in Table 2 by using variables and parameters of an appropriate CGE model.[2] Notation is given in Table 3 at the bottom. Table 3 lists the equality between row sum and column sum for each of the 16 rows and columns (except total) in Table 2. Some of the equalities are broken down into two equalities of row sum and column sum separated by adding an aggregate total (i.e., equalities 5), 6), 7), 8), 9) 10) and 11)), but the two separated equalities when

[2] The model here is the same as Lofgren (2003a, pp.23-32) basically, though notation is changed (shortened) partly.

Table 1. SAM (Social Accounting Matrix): A Numerical Illustration

	AGR–A	NAGR–A	AGR–X	NAGR–X	AGR–Q	NGAR–Q	LAB	CAP	U–HHD	R–HHD	GOV	S–I	YTAX	STAX	TAR	ROW	TOTAL
AGR–A			279														279
NAGR–A				394													394
AGR–X					249											30	279
NAGR–X						394										0	394
AGR–Q	84	55							30	49	13	28					259
NAGR–Q	50	99							165	92	67	85					558
LAB	72	105															177
CAP	73	135															208
U–HHD							95	125			25					40	285
R–HHD							82	83			5					16	186
GOV													25	30	39	15	109
S–I									70	40	−1					4	113
YTAX									20	5							25
STAX					10	20											30
TAR					0	39											39
ROW					0	105											105
TOTAL	279	394	279	394	259	558	177	208	285	186	109	113	25	30	39	105	

Note: Activities (A) are identical with commodities (C), i.e., A=C. X means joint products. Q means composite goods.
Source: Lofgren (2003a), Table 6, p.22.

Table 2. SAM(Social Accounting Matrix): A CGE Specification

	1) A1	2) A2	3) X1	4) X2	5) Q1	6) Q2	7) L	8) K	9) HU	10) HR	11) GOV	12) S-I	13) YTAX	14) STAX	15) TAR	16) ROW	TOTAL
1) A1			PX1・X1														PA1・A1
2) A2				PX2・X2													PA2・A2
3) X1					PD1・D1										TE1	EXR・pwe1・E1	PX1・X1
4) X2						PD2・QD2									TE2	EXR・pwe2・E2	PX2・X2
5) Q1	PQ1・QINT11	PQ1・QINT12							PQ1・QHU1	PQ1・QHR1	PQ1・QG1	PQ1・QINV1					PQ1・Q1
6) Q2	PQ2・QINT21	PQ2・QINT22							PQ2・QHU2	PQ2・QHR2	PQ2・QG2	PQ2・QINV2					PQ2・Q2
7) L	PL・λ1L1	PL・λ2 L2															PL・λ・L
8) K	PK・μ1K1	PK・μ2 K2															PK・μ・K
9) HU							αu PLλL	βu PKμK			TRug					EXR・TRuf	YHu
10) HR							αr PLλL	βr PKμK			TRrg					EXR・TRrf	YHr
11) GOV													YTAX	STAX	TAR	EXR・TRgf	YG
12) S-I									su (1−tyu)・YHu	sr (1−tyr)・YHr	SAVg					EXR・SAVf	SAV
13) YTAX									tyu・YHu	tyr・YHr							YTAX
14) STAX					STAX1	STAX2											STAX
15) TAR					TM1	TM2											TAR
16) ROW					EXR・pwm1・M1	EXR・pwm2・M2											M
TOTAL	PA1・A1	PA2・A2	PX1・X1	PX2・X2	PQ1・Q1	PQ2・Q2	PL・λ・L	PK・μ・K	YHu	YHr	YG	INV	YTAX	STAX	TAR	E+TRf +SAVf	

Note: This table is a CGE specification of Table 1, using variables and parameters of a possible CGE model. See Lafgren (2003a) for a possible CGE model. See Table 3 for notation.

Table 3. Equalities between Row Sum and Column Sum in SAM (Table 2) and the Walras' Law

1)	$PX1\ X1 = PQ1\ QINT11 + PQ2\ QINT21 + PL\ \lambda 1\ L1 + PL\ \lambda 2\ L2$	
2)	$PX2\ X2 = PQ1\ QINT12 + PQ2\ QINT22 + PK\ \mu 1\ K1 + PK\ \mu 2\ K2$	
3)	$PD1\ D1 + EXR\ pwe1E1 - TE1 = PX1\ X1$	
4)	$PD2\ D2 + EXR\ pwe2\ E2 - TE2 = PX2\ X2$	
5)	$PQ1\ (QINT11+QINT12+QHu1+QHr1+QG1+QINV1) = PQ1\ Q1$ ->	$QINT11+QINT12+QHu1+QHr1+QG1+QINV1=Q1$
6)	$PQ2\ (QINT21+QINT22+QHu2+QHr2+QG2+QINV2) = PQ2\ Q2$ ->	$QINT21+QINT22+QHu2+QHr2+QG2+QINV2=Q2$
5')	$PQ1\ Q1 = PD1\ D1 + EXR\ pwm1\ QM1 + TM1 + STAX1$	
6')	$PQ2\ Q2 = PD2\ D2 + EXR\ pwm2\ QM2 + TM2 + STAX2$	
7)	$PL\ (\lambda 1\ L1 + \lambda 2\ L2) = PL\ \lambda\ L$ ->	$\lambda 1\ L1 + \lambda 2\ L2 = \lambda\ L$
8)	$PK\ (\mu 1\ K1 + \mu 2\ K2) = PK\ \mu\ K$ ->	$\mu 1\ K1 + \mu 2\ K2 = \mu\ K$
7')	$PL\ \lambda\ L = (\alpha 1 + \alpha 2)\ PL\ \lambda\ L$ where $\alpha 1 + \alpha 2 = 1$	
8')	$PK\ \mu\ K = (\beta 1 + \beta 2)\ PK\ \mu\ K$ where $\beta 1 + \beta 2 = 1$	
9)	$\alpha u\ PL\ \lambda\ L + \beta u\ PK\ \mu\ K + TRug + EXR\ TRuf = YHu$	
10)	$\alpha r\ PL\ \lambda\ L + \beta r\ PK\ \mu\ K + TRrg + EXR\ TRrf = YHr$	
9')	$YHu = PQ1\ QHu1 + PQ2\ QHr1 + su\ (1-tyu)YHu + tyu\ YHu$	
10')	$YHr = PQ1\ QHr2 + PQ2\ QHr2 + sr\ (1-tyr)\ YHr + tyr\ YHr$	
11)	$YTAX + STAX + TAR + EXR\ TRgf = YG$	
11')	$YG = P1\ QG1 + P2\ QG2 + TRug + TRrg + SG$	
12)	$su\ (1-tyu)\ YHu + sr\ (1-tyr)\ YHr + SAVg + EXR\ SAVf = SAV$	
12')	$INV = P1\ QINV1 + P2\ QINV2$	
12'')	$SAV = INV$ ->	$SAV = INV$
13)	$tyu\ YHu + tyr\ YHr = YTAX$	
14)	$STAX1 + STAX2 = STAX$	
15)	$TM1 + TM2 + TE1 + TE2 = TAR$	
16)	$EXR\ pwm1M1 + EXR\ pwm2\ M2 = EXR\ pwe1E1 + EXR\ pwe2\ E2 + EXR\ TRuf + EXR\ TRrf + EXR\ TRgf + EXR\ SAVf$	-> $pwm1M1+pwm2M2 = pwe1E1+pwe2E2+TRuf+TRrf+TRgf+SAVf$
Walras' Law (i.e., sum of row sums $\equiv$ sum of column sums):		
17)	$PQ1\ (QINT11 + QINT12 + QHu1 + QHr1 + QG1 + QINV1 - Q1)$	5) -> PQ1
	$+ PQ2\ (QINT21 + QINT22 + QHu2 + QHr2 + QG2 + QINV2 - Q2)$	6) -> PQ2
	$+ PL\ (\lambda 1\ L1 + \lambda 2\ L2 - \lambda L)$	7) -> λ
	$+ PK\ (\mu 1\ K1 + \mu 2\ K2 - \mu K)$	8) -> μ
	$+ (SAV - INV)$	12'') -> numeraire
	$+ EXR\ (pwm1QM1 + pwm2\ QM2 - pwe1\ QE1 - pwe2\ QE2 - TRf - SAVf)$	16) -> EXR
	$\equiv 0$	
f1)	$L1 + L2 = L$	f1) -> PL or L
f2)	$K1 + K2 = K$	f2) -> PK or μi (i=1,2)

Note: See rows and columns of Table 2 for the left and right hand sides of 16 equations respectively above.
Notation: Xi = output of activity i (i=1,2), PXi = price of Xi, Di = domestic supply of or demand for commodity i, PDi = price of Di , Ei = export supply of commodity i , EXR = exchange rate, pwei = world export price of commodity i, TEi = export tax of comodity i, Qi = composite goods i, PQi = price of Qi, QINTij = intermediate inputs of composite goods (i,j = 1,2), pwmi = world import price of commodity i, TMi = import tariffs on commodity i, QMi = import demand for commodity i, QHui = urban household expenditure of composite goods i, QHri = rural household expenditure of composite goods i, QGi = government expenditure of composite goods i, QINVi = investment demand for composite goods i, STAX = sales tax, Li = labor demand of activity i, L = total supply of (or demand for) labor, Li = demand for laboy by activity i, PL = price of labor, λ = labor efficienciy, λi = labor efficiency of activity i, Ki = capital stock of activity i, K = total capital stock, PK = rental price of capital, μ = capital efficiency, μi= capital efficiency of activity I, αi = distribution of labor income, βi = distribution of capital income, TRug = transfer to urban household from government, TRuf = transfer to urban household from abroad, TRrg = transfer to rural household from government, TRrf = transfer to rural household from abroad, YHu = urban household income, YHr = rural household income, tyu = urban income tax rate, tyr = rural income tax rate, su = urban saving rate, sr = rural saving rate, YTAX = total income tax, STAX = total sales tax, YG = government revenue, TAR = tariffs and export tax, SAVg = government saving, SAVf = foreign saving, SAV = total saving, INV = total investment.

combined become identical with the original one. The same is true for equality 12) which is broken down into three equalities using two aggregate totals. These 16 equalities constitute an essential part of the whole CGE system[3], representing either identical equations or equilibrium conditions. Let us check the 16 equalities one by one.

Equalities 1) and 2) are identities which equate value of output with value of input cost. The identities must always be maintained in the model by assuming production function of constant returns to scale and marginal conditions or by determining profits as residuals. Note that wage rate is different between sectors by constant efficiency coefficients $\lambda 1$ and $\lambda 2$. The same is true also for rental rate of capital. Equalities 3) and 4) are also identities to equate value of output with value of domestic and export sales, which must be maintained in the model by proper functions of commodity transformation.

Equalities 5) and 6) are demand-supply equilibrium conditions for composite goods, which determine market-clearing equilibrium prices of those goods (PQ1 and PQ2). On the other hand, equalities 5') and 6') are identities to define supply value of composite goods in terms of value of imports and domestic production, which are maintained usually by assuming Armington hypothesis based on homogeneous functions for composite goods.

Contrary to ordinary understanding, equalities 7) and 8) are not equilibrium conditions but identities to define overall efficiency coefficients for labor (λ) and capital (μ), respectively. λ and μ are solved to be equal to one at the starting point for bench mark solution or to be different from one for other solutions with the levels of (L1, L2 and L) or (K1, K2 and K) given by factor market equalities, i.e., f1) and f2) at the bottom of Table 3. When factor prices are flexible, equilibrium conditions f1) and f2) with fixed levels of factor supply (L and K) will determine equilibrium factor prices (PL and PK) so as to clear the factor markets. When wage rate (PL) is rigid and fixed, labor supply (L) will adjust to total demand (L1+L2) as in the case of micro structuralist model. When capital stocks are not mobile between sectors but fixed by sectors (K1, K2, and K=K1+K2) as in the case of neoclassical CGE models for developing countries, rental rate of capital will be determined at different levels for different sectors, resulting in new efficiency coefficients ($\mu 1$ and $\mu 2$).

Equalities 7') and 8') are identities to distribute factor income to urban and rural households by constant allocation shares (α's and β's). Equalities 9) and 10) are identities to define income of urban and rural households. Equalities 9') and 10') are

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[3] Other essential parts are behavioral equations such as marginal conditions and technological equations such as production function, which do not appear explicitly in SAM.

again identities to allocate household income net of saving and tax payments to consumption expenditures of composite goods. The identities must always be maintained by adopting proper consumption functions.

Equalities 11) and 11') are identities which first define government revenue and then allocate it to government expenditures after deducting saving and transfer payments. The latter identity must always be maintained by proper allocation functions. Equalities 12) and 12') are identities which define total saving in value (SAV) and total investment in value (INV), respectively, while equality 12") is basically an equilibrium condition as discussed below in connection with Walras' Law.

Equalities 13), 14) and 15) are identities which define income tax (YTAX), sales tax (STAX) and tariffs and export duties (TAR), respectively. The final equality 16) is basically an equilibrium condition in the market of foreign exchanges which equates value of imports in US dollars (i.e., demand for US dollars) with value of exports, transfer receipts and capital inflow in US dollars (i.e., supply of US dollars).

It is noted that, in Table 2, sum of row sums is identically equal to sum of column sums since both sums are equal to sum of all elements:

$$\Sigma_i(\Sigma_j z_{ij}) \equiv \Sigma_j(\Sigma_i z_{ij}) \equiv \Sigma_i \Sigma_j z_{ij} \quad (z_{ij} = \text{element of i-j cell in Table 2})$$

Therefore, by adding up all the equalities above (eqs.1- 16 in Table 3), we get overall aggregate identity leading to Walras' Law, i.e., total excess demand in value must identically be zero (eq.17 in Table 3), so that one equilibrium condition (i.e., excess demand = 0) becomes redundant when all others hold. In deriving eq.17), identities are all dropped except eqs.7) and 8), which are explicitly included in order to show a specific nature of the labor market in terms of efficiency units in standard CGE models, which assumes constant relative levels (λi or μi) between sectors for each factor price.

3. Implications of Walras' Law on micro and macro closures

Let us first consider the case of clearing factor market (say, labor) in terms of efficiency units. In this case, total supply of labor (L) and overall efficiency coefficient (λ) are given exogenously and the market clearing price (PL) is obtained by the equilibrium condition 7), giving L1 and L2 as employments by sector. However, these sector employments do not satisfy the supply-demand equality in original units shown by eq. f1), namely $L1+L2 \neq L$, unless the relative wage levels between sectors (λi) are always equal to one. Total employment can be bigger or smaller than total available labor, depending on situations. This is not an acceptable specification of the labor market. We must attain the supply-demand equilibrium for labor in original units as in eq. f1) to get equilibrium wage (PL), determining overall efficiency (λ) by eq.7) which is now the identity but not the equilibrium condition. The same is true for the capital market. The supply-demand equilibrium for capital should be attained by original units as in eq. f2), resulting in the determination of overall efficiency (μ) by the identity 8).

The above is a micro closure of factor markets especially for the neoclassical CGE models of developed countries. Alternative micro closure is usually adopted for developing capital market by fixing capital stocks by sector. Different micro closures of structuralist type are often adopted for developing labor markets by fixing wage rate exogenously, assuming supply adjustment of labor to demand. These alternative cases have already been discussed in the previous section, but it is noted here that eqs. f1) and f2) are no longer equilibrium conditions but identities. An important fact must be noted in connection with Walras' Law in standard as well as alternative micro closures of factor markets. That is, the supply-demand equalities in factor markets (eqs. f1) and f2)) are irrelevant to Walras' Law whether they are equilibrium conditions or identities. This is because eqs. f1) and f2) are outside of the aggregate identity (eq.17)) which leads to Walras' Law and do not affect eq.17) at all. This means that any of the factor prices cannot be taken as numeraire, which must be selected from the prices of composite goods (eq.5)), nominal saving or investment (eq.12"), and foreign exchanges (eq.16)).

Let us next consider the markets directly relevant to Walras' Law by dropping labor identities in efficiency units from the aggregate one:

17') $$\begin{aligned} & PQ1\,(QINT11 + QINT12 + QHu1 + QHr1 + QG1 + QINV1 - Q1) \\ & + PQ2\,(QINT21 + QINT22 + QHu2 + QHr2 + QG2 + QINV2 - Q2) \\ & + (SAV - INV) \\ & + EXR\,(pwm1QM1 + pwm2\,QM2 - pwe1\,QE1 - pwe2\,QE2 - TRf - SAVf) \\ & \equiv 0 \end{aligned}$$

This aggregate identity consists of two equilibrium conditions for composite goods (micro closures), one equilibrium condition for nominal saving and investment (macro closure), and one equilibrium condition for foreign exchanges (macro closure). The four equilibrium conditions are not independent due to the aggregate identity above. We must drop one of the four as redundant and set the corresponding price as numeraire. The saving-investment equilibrium (SAV−INV = 0) is the most natural condition to be dropped as redundant. Then, numeraire is the price of nominal saving or investment, which is unitary or always one, so that the other prices (PQ1, PQ2 and EXR) relative to this numeraire are determined in their absolute levels.[4] If one of the other prices (say,

[4] When the model allows explicitly for financial assets, (SAV−INV) becomes equal to the sum of excess

PQ1) is selected as numeraire by dropping as redundant the supply-demand equilibrium condition (QINT11+QINT12+QHu1+QHr1+QG1+QINV1−Q1 = 0), then the model needs some appropriate price such as interest rate to be determined by the saving-investment equality (SAV−INV = 0), but standard CGE models often lack such price. Saving- or investment-driven closure is usually adopted in standard CGE models but this is the case of treating the saving-investment equality as identity but not equilibrium condition, as discussed below, so that the saving-investment equality becomes irrelevant to Walras' Law and numeraire.

If micro closure of structuralist type is adopted for composite goods, say, for the first goods, then its price (PQ1) is fixed and its supply (or demand) is assumed to adjust to its demand (or supply), changing equilibrium condition into identity which makes the market of the first composite goods irrelevant to Walras' Law and numeraire.

If a macro closure of fixed exchange rate is adopted, then the exchange rate (EXR) is fixed and the foreign saving is usually assumed as adjustment factor to attain supply-demand equality. The market of foreign exchanges is no longer in the framework of Wlaras' Law and numeraire.

Investment driven by saving or saving driven by investment is usually used as macro closure in standard CGE models. This is the case of treating saving-investment equality as identity to define either investment in terms of saving or saving (or saving rate) in terms of investment. This macro closure makes saving-investment equality irrelevant to Walras' Law and numeraire. The framework of Walras' Law and numeraire is complete within the markets of composite goods and foreign exchanges to determine relative prices and real quantities. Prices relative to the numeraire price are usually replaced by prices relative to a general price index which is exogenous by using price index equation. Standard CGE models are self-restrained and confined to the real world consisting of relative prices and real quantities. There is, however, room for being expanded to a world of absolute prices and quantities by introducing new rule of macro closure: keep macro saving-investment equality as equilibrium condition and drop it in solving the system with price index equation dropped together.[5]

4. Summary and conclusion

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demand in the markets of money and other financial assets, reducing itself to the excess demand for money when the markets of other financial assets are cleared in one way or another. Then, the balance between saving and investment coincides with the equilibrium in the money market, resulting in the determination of prices in their absolute levels with the price of money (i.e., unit) as numeraire. See Ezaki (1986) for a CGE model with financial assets.

[5] The price index equation seems to be too restrictive to analyze the case of big inflationary shocks such as oil shock. We are interested not only in change in relative prices but also in inflation but the general price level is exogenous in this formulation.

Using a standard prototype CGE model of Lofgren (2003a), we have derived the aggregate identity which leads to Walras' Law for the system with factor markets expressed in efficiency units. We have clarified two new aspects on the closures of standard CGE model.

First, the supply-demand equalities in factor markets are to be attained in original units before efficiency consideration and irrelevant to Walras' Law whether they are equilibrium conditions or identities. This is because the supply-demand equalities are outside of the aggregate identity which leads to Walras' Law and do not affect it at all. This means that any of the factor prices cannot be taken as numeraire, which must be selected from the prices of composite goods, nominal saving or investment, and foreign exchanges. The supply-demand equalities in efficiency units, on the other hand, give the overall efficiency levels.

Second, the macro saving-investment equality can be regarded as the equilibrium condition to determine the prices of composite goods and the exchange rate in their absolute levels. Either the saving-driven investment or the investment-driven saving is usually adopted for the macro saving-investment closure in the standard CGE model. This macro closure treats saving-investment equality as identity and makes it irrelevant to Walras' Law and numeraire. Therefore, the framework of Walras' Law and numeraire in the standard model is complete within the markets of composite goods and foreign exchanges, resulting in the determination of relative prices and real quantities. The standard CGE model may be said to be restrained and confined to the real world consisting of relative prices and real quantities. There is, however, room for the expansion of standard model to a world of absolute prices and quantities by introducing new rule of macro closure: keep macro saving-investment equality as equilibrium condition and drop it in solving the system with price index equation also dropped together. This system may be more effective than the standard model with exogenous general price index in analyzing the case of drastic inflation such as oil shock.

References:

1. Bergman, L,. "The Development of Computable General Equilibrium Modeling," in L. Bergman, D. Jorgenson and E. Zalai, *General Equilibrium Modeling and Economic Policy Analysis*, Blackwell, 1990, pp.3-30.

2. Dervis, K., J. de Melo, and S. Robinson, *General Equilibrium Models for Development Policy*, Oxford University Press, 1982.

3. Dixon, P. B., and B. R. Parmeter, "Computable General Equilibrium Modeling for

Policy Analysis and Forecasting," in H. M. Amman, D. A. Kendrick and J. Rust, *Handbook of Computational Economics*, Volume I, Elsevier, 1996, pp.3-85.

4. Ezaki, M., "A Computable General Equilibrium Model of the Japanese Economy," in *Kobe Economic and Business Review*, 32nd Annual Report, 1986, pp.55-100.

5. Lofgren, Hans, "Exercises in General Equilibrium Modeling Using GAMS," Revised, Microcomputers in Policy Research 4a, International Food Policy Research Institute, 2003a.

6. ________, "Key to Exercises in CGE Modeling Using GAMS," Revised, Microcomputers in Policy Research 4b, International Food Policy Research Institute, 2003b.

7. ________, R. L. Harris and S. Robinson, "A Standard Computable General Equilibrium (CGE) Models in GAMS, Microcomputers in Policy Research 5, International Food Policy Research Institute, 2002.

8. Robinson, S., "Multisectoral Models," in H. Chenery and T. N. Srinivasan (eds.), *Handbook of Development Economics*, Volume II, North Holland, 1989, pp.885-947.