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Linking National Econometric Models of Japan, U.S.A., and the East and Southeast Asian Countries —A Pilot Study—*

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I Introduction

The East and Southeast Asian countries have close economic realtions with Japan and the United States through trade and capital movements. Quantitative analysis and forecasting of any national economy, therefore, cannot be made properly without allowing for its interdependent relations with other economies. The Project LINK (Ball [1973], Waelbroeck [1976], etc.) is the world-wide research effort which focuses on this aspect of economic interdependency mainly among developed countries in the world. Developing countries are considered only on the aggregate regional basis. For example, all of the South and East Asian countries are aggregated into a single region, for which only an aggregate regional model is constructed based on the average data of the region.[1] Not to mention the heterogeneity of the individual countries, those who wish to analyze Asian economic problems can not be satisfied with the aggregate results for the region.

The Center for Southeast Asian Studies, Kyoto University is now attempting to develop a system of linking national econometric models of East and Southeast Asian countries with those of their major trading partners, *i.e.*, Japan and the United States. The present paper is an outcome of this research project. Since its purpose is to investigate the basic nature and merits of the linked system including Japan, U.S.A. and some East and Southeast Asian countries as a pilot study, it has several limitations in scope and analysis. First, the countries covered in this study are only four: Taiwan, Korea, the Philippines and Thailand. Second, a simple prototype modle, *i.e.*, a ten-equations system of the effective demand type, is employed commonly as

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1) See Waelbroeck [1976], pp. 397–409. In Project LINK, the developing countries are classified into four regions: (a) Latin America, (b) South and East Asia, (c) Middle East and Libya, and (d) Africa excluding Libya.

the country model not only for the four countries mentioned above but also for Japan and U.S.A.[2] Third, exports and imports are treated only in total, *i.e.,* no disaggregation by SITC numbers, and the linkage is allowed only for trade relations, *i.e.,* no capital transactions introduced. Finally, the model here is used for the analysis of economic interdependency based on policy simulations, but not for the forecasting purposes. These limitations in scope and analysis may look serious. However, the link-model developed here can still be favorably compared with the unlinked country model in deriving some basic facts and policy implications which underlie the interdependent relations among Japan, U.S.A. and several East and Southeast Asian countries.[3)]

In Section 2, we will propose a prototype model for linkage and discuss about an iterative method to get the solution of the model. In Section 3, we will provide the ordinary least squares (OLS) estimates of structural equations and check the simulatability of the model from the point of view of the final test or dynamic simulations. In Section 4, on the basis of this dynamic simulations, we will quantify the effects of the changes in policy variables, *i.e.,* government consumption expenditures and exchange rates, and analyze the repercussions among the countries. We will also compare the simulation results of the linked

Table 1 A Prototype Model for Linkage

Country Model $(i=1,\ldots,N-1)$*

(C–1) $Y^i_t=C^i_t+I^i_t+\bar{G}^i_t+X^i_t-M^i_t$

(C–2) $X^i_t(PX^i_o/\bar{r}^i_o)\theta^i=X\$^i_t+\overline{XS\$}^i_t$

(C–3) $M^i_t(PM^i_o/\bar{r}^i_o)\theta^i=M\$^i_t+\overline{MS\$}^i_t$

(C–4) $C^i_t=f[Y^i_t,\ C^i_{t-1},\ \overline{DUM}^i_t]$

(C–5) $I^i_t=f[Y^i_t,\ \overline{DUM}^i_t]$

(C–6) $X\$^i_t=f[WT\$_t,\ X\$^i_{t-1},\ PX\$^i_t/PW\$_t]$

(C–7) $M\$^i_t=f[Y^i_t(PY^i_o/\bar{r}^i_o)\theta^i,\ M\$^i_{t-1},$
$PM\$^i_t(\bar{r}^i_t/\bar{r}^i_o)/(PY^i_t/PY^i_o)]$

(C–8) $PY^i_t=f[Y^i_t/Y^i_b,\ (PM\$^i_t/PM\$^i_b)(\bar{r}^i_t/\bar{r}^i_b)]$

(C–9) $PX^i_t=f[PY^i_t,\ (PW\$_t/PW\$_b)(\bar{r}^i_t/\bar{r}^i_b)]$

(C–10) $PX\$^i_t=f[(PX^i_t/PX^i_o)/(\bar{r}^i_t/\bar{r}^i_o)]$

Trade Model (Linkage)

(T–1) $X\$^{ij}_t=f[Y^j_t(PY^j_o/\bar{r}^j_o)\theta^j,$
$X\$^{ij}_{t-1}, PX\$^i_t/PM\$^j_t,$
$PX\$^i_t(\bar{r}^j_t/\bar{r}^j_o)/(PY^j_t/PY^j_o)]$
$(i, j=1\ldots N-1;\ i\neq j)$

(T–2) $X\$^{Nj}_t=M\$^j_t-\sum_{i=1}^{N-1}X\$^{ij}_t$
$(j=1\ldots N\text{-}1)$

(T–3) $X\$^{iN}_t=X\$^i_t-\sum_{j=1}^{N-1}X\$^{ij}_t$
$(i=1\ldots N\text{-}1)$

(T–4) $X\$^{NN}_t=\bar{\alpha}_t\cdot WT\$_t$

(T–5) $PX\$^{Nj}_t=\bar{\beta}^{Nj}_t\cdot PW\$_t \quad (j=1\ldots N)$

(T–6) $M\$^N_t=\sum_{i=1}^{N}X\$^{iN}_t$

(T–7) $X\$^N_t=\sum_{j=1}^{N}X\$^{Nj}_t$

(T–8) $PX\$^N_t=\sum_{j=1}^{N}PX\$^{Nj}_t\cdot X\$^{Nj}_t/\sum_{j=1}^{N}X\$^{Nj}_t$

(T–9) $WT\$_t=\sum_{i=1}^{N}XS^i_t(=\sum_{j=1}^{N}M\$^j_t)$

(T–10) $PW\$_t=\sum_{i=1}^{N}PX\$^i_t\cdot X\$^i_t/\sum_{i=1}^{N}X\$^i_t$

(T–11) $PM\$^j_t=(\sum_{i=1}^{N-1}PX\$^i_t\cdot X\$^{ij}_t$
$+PX\$^{Nj}_t\cdot X\$^{Nj}_t)/\sum_{i=1}^{N}X\$^{ij}_t$
$(j=1\ldots N)$

* $i=1$: Japan (JPN), $i=2$: U.S.A. (USA), $i=3$: Taiwan (TWN), $i=4$: Korea (KREA), $i=5$: Philippines (PHIL), $i=6$: Thailand (THAI), and $i=N=7$: Rest of the World (ROW).

2) The country model in the present paper is quite similar to the model proposed by Klein and Van Peeterssen [1973] tentatively for France and Italy, in which suitable models were not yet available at the time of starting Project LINK.

3) The present study owes much to the papers collected in Ball [1973] and Waelbroeck [1976]. Moriguchi [1973] and Gana, Hickman and Lau [1977] are also important sources of reference.

system with those of the unlinked country model. In Section 5, some concluding remarks will be given.

II A Prototype Model for Linkage

Table 1 summarizes the prototype model for linkage which is employed in the present paper. The corresponding notation is shown in Table 2. Our model for linkage consists of two parts: country model and trade model. The country model is a system of ten equations (C–1)～(C–10), for which the linear form will be assumed in estimation (*i.e.*, f (A, B,...) means the linear function of A, B,...). The ten-equations system is commonly used for each of the sixc ountries under

Table 2 Notation of the Link Model*

Country i:		
Y	=GNP or GDP at constant prices	(NIS)[a]
C	=Private consumption expenditures at constant prices	(〃)
I	=Gross domestic capital formation at constant prices	(〃)
$\bar{G}$	=Government consumption expenditures at constant prices	(〃)
X	=Exports of goods and services at constant prices	(〃)
M	=Imports of goods and services at constant prices	(〃)
PY	=Implicit deflator of GNP or GDP	(〃)
PX	=Implicit deflator of exports of goods and services	(〃)
$^*PM$	=Implicit deflator of imports of goods and services	(〃)
$\bar{r}$	=Exchange rate per US$	(UN Statistical Yearbook)
θ	=Scale factor which adjusts NIS data to trade data	(Table 4)
$\overline{DUM}$	=Dummy variable which takes *1* for 1974–75 and *0* otherwise	
$X\$$	=Commodity exports at constant US$	(HKL)[b]
$M\$$	=Commodity imports at constant US$	(〃)
$PX\$$	=Deflator of commodity exports in US$	(〃)
$PM\$$	=Deflator of commodity imports in US$	(〃)
$\overline{XS\$}$	=Service exports at constant US$	(computed as residuals)
$\overline{MS\$}$	=Service imports at constant US$	(〃)
Trade relations:		
$X\$^{ij}$	=Commodity exports from country *i* to country *j* at constant US$	(HKL)
$PX\$^{Nj}$	=Deflator of commodity imports of country *j* from ROW ($X\$^{Nj}$)	(〃)
$\bar{\alpha}$	=Ratio of intra-regional commodity trade of ROW countries ($X\$^{NN}$) to world commodity trade ($WT\$$)	(actual ratios)
$\bar{\beta}^{Nj}$	=Ratio of $PX\$^{Nj}$ to world trade deflator ($PW\$$)	(〃)
$WT\$$	=World commodity trade at constant US$	(HKL)
$PW\$$	=Deflator of world commodity trade	(〃)

* Barred variables are exogenous. $PM\$^i$, $WT\$$ and $PW\$$ are treated as exogenous in solving each country model independently without allowing for the trade relations between countries. PM is not used here except for its 1970 value. PM, however, can be introduced into the model as an endogenous variable by employing a statistical relationship: $PM=f(PM\$\cdot r)$.

[a] National Income Statistics.

[b] Hickman, Kuroda and Lau [1977].

Table 3 Measuring Units and Base Years

National Income Statistics Data:			(base year = b)
1. Japan	(GNP)	billions of constant yens	1970
2. U.S.A.	(GNP)	billions of constant US$	1972
3. Taiwan	(GDP)	millions of constant NT$	1971
4. Korea	(GDP)	billions of constant wons	1970
5. Philippines	(GDP)	millions of constant pesos	1967
6. Thailand	(GDP)	millions of constant bahts	1962
International Trade Data:			(base year = o)
All countries		millions of constant US$	1970

Table 4 Parameter Values

	1. JPN	2. USA	3. TWN	4. KREA	5. PHIL	6. THAI
θ	1000	1000	1	1000	1	1
r_o	357.6	1.0	40.10	316	5.729	20.93
r_b	357.6	1.0	40.10	316	3.900	20.84
PX_o	1.000	9.31	.9744	1.000	1.757	1.016
PM_o	1.000	.891	.9611	1.000	1.586	1.080
PY_o	1.001	.9136	.9670	1.000	1.257	1.135
$PM\$_b$	1.000	1.121	1.037	1.000	.914	.870
$PW\$_b$	1.000	1.128	1.044	1.000	.924	.873
Y_b	70613.3	1171.1	261558	2577.36	29515	63793

consideration, though there will be some minor changes in explanatory variables in the actual estimation.[4] The country model here is quite similar to the model proposed by Klein and Van Peeterssen [1973] tentatively for France and Italy and can be characterized as the model of effective demand type since all of the behavioral equations for quantity variables (C–4)~(C–7) are specified as demand functions.

Equation (C–1) is the GNP or GDP identity at constant prices in national income statistics (abbreviated as NIS). Equations (C–2) and (C–3) are the identities at constant prices between the NIS data in national currencies and the international trade data in US dollars, respectively for exports and imports of goods and services. As shown in Table 3, measuring units and base years are different not only from one country to another but also in NIS and international trade data. Therefore, appropriate adjustment factors ($PX_o/r_o\cdot\theta$ and $PM_o/r_o\cdot\theta$) must be applied in the two accounting identities (See Table 4 for parameter values). In the present paper, the data for international *commodity* trade in US dollars are based exclusively on Hickman, Kuroda and Lau [1977]. As a result, the data for international *service* trade in US dollars *XS$* and *MS$*) are derived as residuals by using the accounting identities (C–2) and (C–3).[5] Equation (C–4) is the con-

4) The same is true for the trade model. In this sense, the model presented in Table 1 is called the prototype model.

sumption function of the usual type, where the oil shock dummy (*DUM*) is introduced when necessary, while equation (C–5) is the investment function of the simplest kind. Equations (C–6) and (C–7) are the demand functions for exports and imports, respectively, both of which are determined by the variables of the same nature. Note that in the case of import functions, measuring units and base years of the explanatory variables are adjusted to those of the dependent variables. By such an adjustment, the interpretation and comparison of the coefficient estimates will be made easier and more straightforward.6) Equation (C–8) assumes that the *GNP* deflator is determined by the levels of total demand (index of GNP) and import prices with the base year adjusted. Similarly, equation (C–9) assumes that the export deflator for goods and services of the NIS base is determined by the levels of GNP deflator and world export prices with base year adjusted. The last equation (C–10) represents a statistical relationship between the deflator for exports of goods and services and the deflator for commodity exports.

Our country model, which consists of ten equations can be solved for ten endogenous variables of each country if the data are given *a priori* to both of the predetermined variables (*i.e.*, barred and lagged variables) and the three variables related to foreign countries or world market ($WT\$$, $PW\$$ and $PM\$^i$). This is the case of unlinked country model. The three world variables, however, must be determined in the world market by introducing trade relations among all of the countries in the world. As shown in Table 5, the world in the present paper is divided into six countries and the rest of the world (ROW), and our trade model (*i.e.*, the linkage part of Table 1) describes the trade relations for these seven groups as well as for the entire world.

Equation (T–1) is the key equation for linkage. For the six countries except ROW, it specifies the exports from country i to country j ($X\$^{ij}$) as a demand function of country j, so that it may be called the import function of country j for the exports of country i. The disaggregate import function (T–1) is derived on the basis of the same principle as the aggregate import function (C–7). However, they are different in the treatment of relative prices which represent the price competitiveness in the market of importing country. In other words, the former (T–1) allows for the competitive power of exporting country in the market of importing country in more details than the latter (C–7) by introducing two kinds of relative prices: $PX\$^i/PM\$^j$ (*i.e.*, competition with other countries exporting to country j) and $PX\$^i \cdot r^j/PY^j$ (*i.e.*,

5) These identities are not the exact ones in terms of the actual data. Negative values are derived as residuals for several years on the imports of Taiwan and Korea and for one or two years on the imports of the Philippines and Thailand.

6) Such adjustment is unnecessary when the log-linear form is employed, since any kind of scale adjustment concentrates on the constant term in the actual estimation.

Table 5 Trade Relations with Particular Reference to the ROW Countries in the Link Model*

	1	2	3	4	5	6	N	Total	
1	$\overline{X\$}^{11}$	$X\$^{12}$	$X\$^{13}$	$X\$^{14}$	$X\$^{15}$	$X\$^{16}$	*residuals*	$X\$^{1}$	$PX\$^{1}$
2	$X\$^{21}$	0	$X\$^{23}$	$X\$^{24}$	$X\$^{25}$	$X\$^{26}$		$X\$^{2}$	$PX\$^{2}$
3	$X\$^{31}$	$X\$^{32}$	0	$X\$^{34}$	$X\$^{35}$	$X\$^{36}$		$X\$^{3}$	$PX\$^{3}$
4	$X\$^{41}$	$X\$^{42}$	$X\$^{43}$	0	$X\$^{45}$	$X\$^{46}$		$X\$^{4}$	$PX\$^{4}$
5	$X\$^{51}$	$X\$^{52}$	$X\$^{53}$	$X\$^{54}$	0	$X\$^{56}$		$X\$^{5}$	$PX\$^{5}$
6	$X\$^{61}$	$X\$^{62}$	$X\$^{63}$	$X\$^{64}$	$X\$^{65}$	0		$X\$^{6}$	$PX\$^{6}$
N	*residuals*						$X\$^{NN}$	$X\$^{N}$	$PX\$^{N}$
Total	$M\$^{1}$	$M\$^{2}$	$M\$^{3}$	$M\$^{4}$	$M\$^{5}$	$M\$^{6}$	$M\$^{N}$	$WT\$$	$PW\$$
	$PX\$^{N1}$	$PX\$^{N2}$	$PX\$^{N3}$	$PX\$^{N4}$	$PX\$^{N5}$	$PX\$^{N6}$	$PX\$^{NN}$		
	$PM\$^{1}$	$PM\$^{2}$	$PM\$^{3}$	$PM\$^{4}$	$PM\$^{5}$	$PM\$^{6}$	$PM\$^{N}$		

* Note that the trade data here are based on Hickman, Kuroda and Lau [1977] where Ryukyu is treated as part of the Japanese territory throughout the postwar period though it had been under the rule of U.S.A. until 1972. As a result, the diagonal element which corresponds to Japan (country 1) does not vanish before 1972 so that it is treated as exogenous in the model.

competition with the importing country).

Equations (T–2)~(T–8) are concerned about the ROW countries, for which neither export and import functions such as (C–6), (C–7) and (T–1), nor export price function such as (C–10) are specified explicitly. Instead, exports and imports of the ROW sector are determined as residuals by equations (T–2) and (T–3) as is illustrated in Table 5. Furthermore, the intra-regional trade ($X\$^{NN}$) and the export prices ($PX\$^{NJ}$'s) of the ROW countries are assumed to be proportional to total world trade ($WT\$$) and world export price ($PW\$$), respectively, by equations (T–4) and (T–5). The proportionality factors (α and β's) are treated as exogenous and their data are the actual ratios, so that the introduction of equations (T–4) and (T–5) will be almost equivalent with the exogenous treatment of $X\$^{NN}$ and $PX\$^{NJ}$.[7] We need, for the ROW sector, such devices as equations (T–4) and (T–5) in order to avoid misleading results in case of the policy simulations (See Section 4). That is to say, $X\$^{NN}$ and $PX\$^{NJ}$ are assumed to maintain their ratios to $WT\$$ and $PW\$$, respectively, at the actual historical levels even when the data for policy variables in some country are changed to analyze the policy effects based on the simulation method. The three remaining equations (T–6)~(T–8) are all concerned about the aggregate identities in quantity or price for the ROW countries taken as a whole.

Equations (T–9) and (T–10) are also the aggregate identities in quantity or

7) Concerning the world variables ($WT\$$ and $PW\$$), the final test based on the former shows slightly bigger deviations from actual values than the final test based on the latter. Note that the data for α are distributed between 0.634 and 0.667 with a slightly downward trend.

price for the world as a whole. Note that total world trade ($WT\$$) can be defined either from export side or from import side, since total exports ($\Sigma X\$$) and total imports ($\Sigma M\$$) are always identical in the present model. The last equation (T–11) defines the import price index for each country as well as for the ROW sector. Price indexes in the present paper are defined basically as implicit deflators (such as equations (T–8), (T–10) and (T–11)), so that the world identity between total exports and total imports is valid not only in terms of quantity (i.e., $\Sigma X\$=\Sigma M\$$) but also in terms of value (i.e., $\Sigma PX\$\cdot X\$=\Sigma PM\$\cdot M\$$).

Unlike the system of Project LINK,[8] our prototype model for linkage determines the imports of ROW sector from other countries ($X\$^{iN}$) as residuals by equation (T–3) without suppressing the export function (C–6) of each country. It may be possible, however, to introduce explicitly the import functions of ROW countries based on the principles similar to equation (T–1), and to replace the aggregate export function (C–6) by the sum of component exports in each country. Similarly, for the exports of ROW sector to other countries ($X\$^{Nj}$), it is possible (and easier than the case of the imports of ROW sector above) to introduce the import functions of each country from ROW, and to replace the aggregate import function (C–7) by the sum of component imports in each country. Our prototype model for linkage may be modified in this direction on the treatment of ROW sector. However, the present model does not seem to be inferior to the possible modified version, unless we succeed in developing a model for the ROW sector which can explain the import behavior of the sector well.

Our model for linkage is a system of non-linear equations for which some iterative procedure is unavoidable to get the solution. Figure 1 illustrates an iterative method which is adopted in the present paper.[9] Note that the country model here is essentially a linear system, *i.e.*, linear in endogenous variables, if the data for $WT\$$, $PW\$$ and $PM\$^i$ are fixed *a priori*, since $PM\$\cdot r/PY$ in equation (C–7) is reversed into $PY/PM\$\cdot r$ in the actual estimation. Therefore, the solution for ten endogenous variables in the country model can easily be obtained for each country under the given $WT\$$, $PW\$$ and $PM\$^i$. When the data for $WT\$$, $PW\$$ and $PM\$^i$ are set equal to their actual values which are the initial values of our iterative process, we get the solution for the unlinked country model, with which the first iteration starts. (See the upper-left part of Figure 1). The solution of the unlinked country model is used to compute the left-hand side variables of the trade model (i.e., equations (T–1)~(T–11)), the last three of which are again $WT\$$, $PW\$$ and $PM\$^i$. (See the upper-right part of Figure 1). The new data

8) See Gana, Hickman and Lau [1977], which gives a good summary of various linking methods employed in Project LINK.

9) It is similar to the iterative method employed in Klein and Van Peeterssen [1973] (Fig. 4, p. 454).

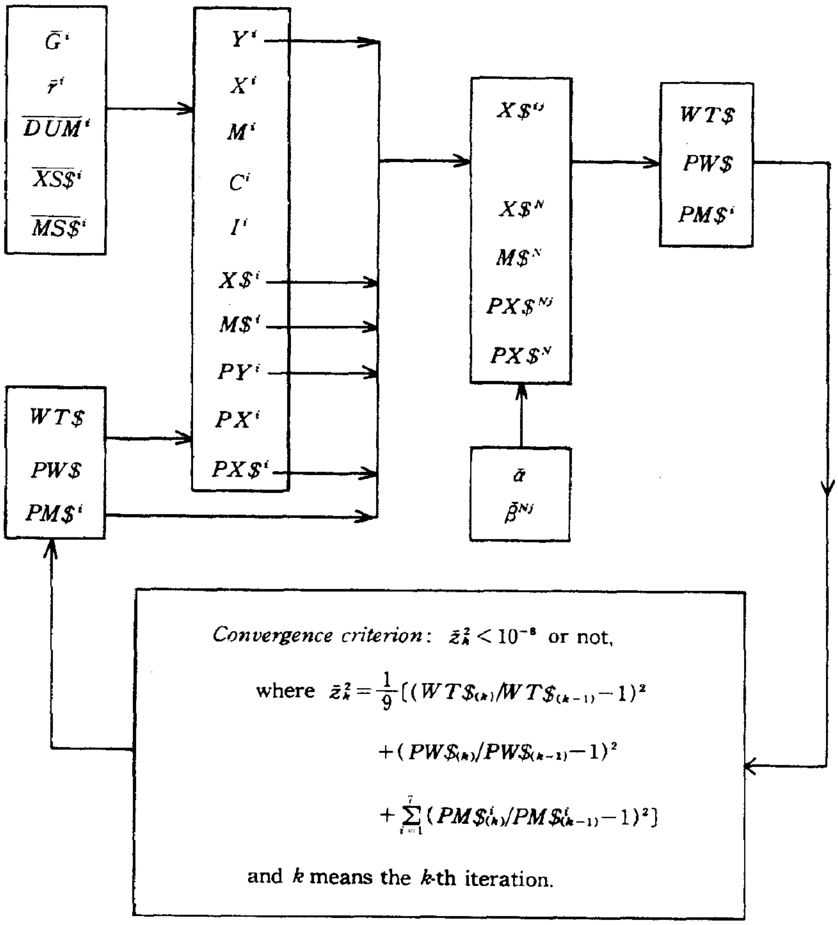

Fig. 1 An Iterative Solution of the Model*

* *WT\$*, *PW\$* and *PM\$*^{i} are exogenous in the case of unlinked country model, *i.e.*, in solving each country model independently without allowing for the trade relations between countries. The three variables become endogenous in solving the whole linked system.

for *WT\$*, *PW\$* and *PM\$*^{i} thus obtained give a new solution for the country model, with which the second iteration starts. This iterative process continues until the convergence criterion shown in Figure 1 is satisfied, and we get the solution for the whole linked system.

III Estimation and Simulatability of the Model

The OLS method is applied in the present study to the prototype model of Table 1 or its variations. The estimation period is 1961–1975 for the five countries except for Korea.[10] The NIS data in Korea are available only from 1962 so

10) The international trade data by Hickman, Kuroda and Lau [1977] are available for 1955–1975. The NIS data of Japan, U.S.A. and Taiwan are available from the biginning of the 1950's until recently, while those of the Philippines and Thailand are available for 1960–1975.

that the Korean country model and import functions are estimated for the period 1963–1975 with due allowance for lagged variables. As a result, the simulatability of our linked system is checked for the period 1963–1975. The results of estimation are presented in Table 6 for the country model of six countries and in Table 7 for the trade model consisting of thirty import functions, *i.e.*, equation (T–1) of Table 1.

Table 6 Structure of the Country Models (OLS Estimates)*

Country Model 1 (*Japan*): 1961–1975

1. $Y = C + I + \bar{G} + X - M$
2. $X(PX_o/\bar{r}_o)\theta = X\$ + \overline{XS\$}$
3. $M(PM_o/\bar{r}_o)\theta = M\$ + \overline{MS\$}$
4. $C = 2161.2 + .23812\ Y + .52470\ C_{-1}$ — $R^2 = .999$, $DW = 2.072$
   (4.91) (4.54) (4.66)
5. $I = -5141.3 + .45286\ Y - 3652.5\ \overline{DUM}$ — $R^2 = .998$, $DW = 1.773$
   (−5.93) (30.4) (−3.77)
6. $X\$ = 9385.7 + .065188\ WT\$ + .29351\ X\$_{-1} - 15564.4\ (PX\$/PW\$)$ — $R^2 = .998$, $DW = 1.807$
   (.860) (3.98) (1.49) (−1.38)
7. $M\$ = -2412.5 + .085781\ Y(PY_o/r_o)\theta + .10365\ M\$_{-1}$ — $R^2 = .994$, $DW = 1.798$
   (−2.10) (4.55) (.535)
8. $PY = .14378 + .52804\ (Y/Y_b) + .34907\ (PM\$/PM\$_b)(\bar{r}/\bar{r}_b)$ — $R^2 = .999$, $DW = 1.988$
   (12.1) (34.2) (27.1)
9. $PX = .27570 + .31271\ PY + .41041\ (PW\$/PW\$_b)(\bar{r}/\bar{r}_b)$ — $R^2 = .999$, $DW = 2.501$
   (10.9) (6.24) (7.58)
10. $PX\$ = -.04546 + 1.06914\ (PX/PX_o)/(\bar{r}/\bar{r}_o)$ — $R^2 = .998$, $DW = .776$
   (−.784) (20.5)

Country Model 2 (*U.S.A.*): 1961–1975

1. $Y = C + I + \bar{G} + X - M$
2. $X(PX_o/\bar{r}_o)\theta = X\$ + \overline{XS\$}$
3. $M(PM_o/\bar{r}_o)\theta = M\$ + \overline{MS\$}$
4. $C = -22.105 + .27404\ Y + .61201\ C_{-1} - 9.412\ \overline{DUM}$ — $R^2 = .999$, $DW = 1.907$
   (−1.44) (2.57) (3.59) (−.913)
5. $I = -33.628 + .18795\ Y - 31.183\ \overline{DUM}$ — $R^2 = .996$, $DW = 1.679$
   (−1.61) (9.02) (−3.36)
6. $X\$ = 36559.8 + .083602\ WT\$ + .28930\ X\$_{-1} - 32193.3\ (PX\$/PW\$)$ — $R^2 = .999$, $DW = 1.890$
   (3.69) (6.62) (2.52) (−3.40)
7. $M\$ = -27698.3 + .024799\ Y(PY_o/r_o)\theta + .73772\ M\$_{-1}$
   (−3.56) (1.84) (4.47)
   $+ 16215.1\ (PY/PY_o)/PM\$(\bar{r}/\bar{r}_o)$ — $R^2 = .998$, $DW = 2.564$
   (3.24)
8. $PY = .03637 + .64786\ (Y/Y_b) + .28209\ (PM\$/PM\$_b)(\bar{r}/\bar{r}_b)$ — $R^2 = .999$, $DW = 1.061$
   (.562) (6.74) (8.02)
9. $PX = .03323 + .36178\ PY + .62599\ (PW\$/PW\$_b)(\bar{r}/\bar{r}_b)$ — $R^2 = .999$, $DW = 1.253$
   (1.23) (5.92) (18.7)

Table 6 (continued)

10. $PX\$=-.00798+1.00150\ (PX/PX_o)/(\bar{r}/\bar{r}_o)$ $\quad R^2=1.000$
 $(-1.23)\quad(166.1)$ $\quad DW=1.593$

Country Model 3 (*Taiwan*): 1961–1975

1. $Y=C+I+\bar{G}+X-M$
2. $X(PX_o/\bar{r}_o)\theta=X\$+\overline{XS\$}$
3. $M(PM_o/\bar{r}_o)\theta=M\$+\overline{MS\$}$
4. $C\ =10148.6+.30915\ Y+.38737\ C_{-1}$ $\quad R^2=.999$
 $(5.47)\quad(5.76)\quad(3.36)$ $\quad DW=1.830$
5. $I\ =-23802.9+.35345\ Y$ $\quad R^2=.988$
 $(-4.69)\quad(15.7)$ $\quad DW=2.192$
6. $X\$\ =-28.064+.0040352\ WT\$+.87673\ X\$_{-1}-687.07\ PX\$$ $\quad R^2=.995$
 $(-.071)\quad(2.69)\quad(4.97)\quad(-2.65)$ $\quad DW=1.368$
7. $M\$=-287.15+.31451\ Y(PY_o/r_o)\theta+.54402\ M\$_{-1}-518.69\ PM\$(\bar{r}/\bar{r}_o)$ $\quad R^2=.994$
 $(-.549)\quad(2.97)\quad(1.48)\quad(-1.04)$ $\quad DW=1.927$
8. $PY\ =.03387+.28897\ (Y/Y_b)+.66266\ (PM\$/PM\$_b)(\bar{r}/\bar{r}_b)$ $\quad R^2=.999$
 $(1.26)\quad(6.11)\quad(14.9)$ $\quad DW=.993$
9. $PX\ =.15139+.29142\ PY+.58553\ (PW\$/PW\$_b)(\bar{r}/\bar{r}_b)$ $\quad R^2=.998$
 $(2.92)\quad(1.21)\quad(2.54)$ $\quad DW=1.867$
10. $PX\$=.05011+.97130\ (PX/PX_o)/(\bar{r}/\bar{r}_o)$ $\quad R^2=.994$
 $(.565)\quad(12.4)$ $\quad DW=1.635$

Country Model 4 (*Korea*): 1963–1975

1. $Y=C+I+\bar{G}+X-M$
2. $X(PX_o/\bar{r}_o)\theta=X\$+\overline{XS\$}$
3. $M(PM_o/\bar{r}_o)\theta=M\$+\overline{MS\$}$
4. $C\ =38.734+.18744\ Y+.78309\ C_{-1}-115.15\ \overline{DUM}$ $\quad R^2=.999$
 $(.745)\quad(1.69)\quad(4.10)\quad(-3.58)$ $\quad DW=1.325$
5. $I\ =-225.85+.33148\ Y$ $\quad R^2=.989$
 $(-3.72)\quad(14.4)$ $\quad DW=1.208$
6. $X\$\ =462.57+.0040811\ WT\$+.74861\ X\$_{-1}-1268.9\ (PX\$/PW\$)$ $\quad R^2=.992$
 $(.564)\quad(2.66)\quad(3.92)\quad(-1.36)$ $\quad DW=2.752$
7. $M\$=-1159.4+.32393\ Y(PY_o/r_o)\theta+480.42\ (PY/PY_o)/PM\$(\bar{r}/\bar{r}_o)$ $\quad R^2=.992$
 $(-2.51)\ (15.7)\quad(1.02)$ $\quad DW=1.687$
8. $PY\ =-.24856+1.05279\ (Y/Y_b)+.19063\ (PM\$(PM\$_b)(\bar{r}/\bar{r}_b)$ $\quad R^2=.995$
 $(02.55)\quad(5.44)\quad(2.17)$ $\quad DW=1.742$
9. $PX\ =.29912+.25451\ PY+.46809\ (PW\$/PW\$_b)(\bar{r}/\bar{r}_b)$ $\quad R^2=.999$
 $(9.87)\quad(2.76)\quad(7.81)$ $\quad DW=1.857$
10. $PX\$=-.07561+1.03456\ (PX/PX_o)/(\bar{r}/\bar{r}_o)$ $\quad R^2=.981$
 $(-.266)\quad(4.03)$ $\quad DW=.993$

Country Model 5 (*Philippines*): 1961–1975

1. $Y=C+I+\bar{G}+X-M$
2. $X(PX_o/\bar{r}_o)\theta=X\$+\overline{XS\$}$
3. $M(PM_o/\bar{r}_o)\theta=M\$+\overline{MS\$}$
4. $C\ =691.15+.084134\ Y+.89105\ C_{-1}$ $\quad R^2=.999$
 $(1.32)\quad(.750)\quad(5.07)$ $\quad DW=1.996$

5. $I = -3244.9 + .31016\,Y$ $R^2 = .989$, $DW = .764$
   (−3.33) (10.1)

6. $X\$ = 1006.0 + .0015488\,WT\$ + .35545\,X\$_{-1} - 816.53\,(PX\$/PW\$)$ $R^2 = .995$, $DW = 2.427$
   (4.64) (2.54) (1.39) (−3.20)

7. $M\$ = -491.98 + .12315\,Y(PY_o/r_o)\theta + .50386\,M\$_{-1}$
   (−1.29) (2.54) (2.47)
   $+258.27\,(PY/PY_o)/PM\$(\bar{r}/\bar{r}_o)$ $R^2 = .995$, $DW = 1.504$
   (1.54)

8. $PY = .12973 + .39453\,(Y/Y_b) + .45522\,(PM\$/PM\$_b)(\bar{r}/\bar{r}_b)$ $R^2 = .999$, $DW = 1.860$
   (1.02) (2.38) (13.7)

9. $PX = -.75114 + 1.82399\,PY$ $R^2 = .978$, $DW = 2.377$
   (−3.89) (13.4)

10. $PX\$ = -.02339 + 1.04048\,(PX/PX_o)/(r/r_o)$ $R^2 = .994$, $DW = .918$
   (−.360) (17.4)

Country Model 6 (*Thailand*): 1961–1975

1. $Y = C + I + \bar{G} + X - M$
2. $X(PX_o/\bar{r}_o)\theta = X\$ + \overline{XS\$}$
3. $M(PM_o/\bar{r}_o)\theta = M\$ + \overline{MS\$}$
4. $C = 2891.2 + .26087\,Y + .62204\,C_{-1}$ $R^2 = .999$, $DW = 2.104$
   (2.57) (2.72) (3.81)

5. $I = -3871.9 + .27480\,Y$ $R^2 = .989$, $DW = .776$
   (−1.48) (11.7)

6. $X\$ = 566.97 + .00095139\,WT\$ + .51651\,X\$_{-1} - 416.49\,(PX\$/PW\$)$ $R^2 = .996$, $DW = 2.204$
   (2.91) (1.57) (1.94) (−2.46)

7. $M\$ = -820.48 + .12524\,Y(PY_o/r_o)\theta + .38497\,M\$_{-1}$
   (−2.58) (2.88) (1.71)
   $+763.05\,(PY/PY_o)/PM\$(\bar{r}/\bar{r}_o)$ $R^2 = .998$, $DW = 1.739$
   (2.91)

8. $PY = .42928 + .079720\,(Y/Y_b) + .49953\,(PM\$/PM\$_b)(\bar{r}/\bar{r}_b)$ $R^2 = .999$, $DW = 1.208$
   (11.8) (2.27) (11.0)

9. $PX = -.23024 + .53038\,PY + .61945\,(PW\$/PW\$_b)(\bar{r}/\bar{r}_b)$ $R^2 = .993$, $DW = 1.512$
   (−.775) (.812) (1.52)

10. $PX\$ = -.06977 + 1.08858\,(PX/PX_o)/(\bar{r}/\bar{r}_o)$ $R^2 = .999$, $DW = 1.070$
   (−5.44) (105.6)

* *t*-ratios are shown in brackets. R^2 = coefficient of determination. DW = Durbin-Watson ratio.

Table 7 Structure of the Trade Model (OLS Estimates): 1961–1975*

$X\$^{ij}$	$CONST$	$Y\$^j$	$X\$^{ij}_{-1}$	$PX\$^i/PM\$^j$	$PX\$^i/PY\$^j$	$PX\$^i(r^j/r^j_o)$	R^2 / DW
USA–JPN	3210.1 (1.89)	.020826 (8.73)		−3168.6 (−2.00)			.989 / 1.994
TWN–JPN	−95.301 (−1.71)	.0014902 (2.95)	.35942 (1.69)				.954 / 1.710
KREA–JPN	210.64 (.569)	.0033074 (3.00)	.26094 (.830)	−598.97 (−1.32)			.937 / 2.103
PHIL–JPN	219.20 (2.51)	.0015072 (8.27)			−127.47 (−1.92)		.992 / 2.369

THAI–	−10.511	.00058248	.51616				.994
JPN	(−.875)	(2.58)	(2.40)				1.939
JPN–	1385.6	.0038361	.73816		−3132.7		.992
USA	(.496)	(1.11)	(3.61)		(−2.66)		2.770
TWN–	−59.565	.00056305	.87066		−299.60		.986
USA	(−.165)	(1.56)	(7.37)		(−2.29)		1.009
KREA–	−261.69	.0013645	.48555	−659.83	−170.85		.997
USA	(−1.71)	(2.82)	(1.89)	(−1.87)	(−1.49)		2.634
PHIL–	169.34	.0000277	.76105		−83.998		.993
USA	(2.15)	(.164)	(1.91)		(−1.46)		1.625
THAI–	92.101	.00012011	.24285	−113.14	−16.406		.980
USA	(.986)	(1.97)	(1.17)	(−1.56)	(−.631)		1.904
JPN–	29.163	.12960	.57884			−386.93	.996
TWN	(.198)	(3.18)	(2.43)			(−3.83)	2.516
USA–	1144.5	.10275		−1253.1			.990
TWN	(2.89)	(9.97)		(−3.29)			2.356
KREA–	12.229	.0043326	.31394	−27.366			.958
TWN	(.988)	(3.24)	(1.12)	(−1.91)			2.305
PHIL–	10.284	.0036103	.25334			−15.804	.960
TWN	(3.13)	(4.05)	(1.15)			(−3.58)	2.478
THAI–	−16.498	.0076884					.891
TWN	(−2.22)	(5.64)					2.449
JPN–	3143.2	.11434		−3088.5	−165.80		.993
KREA	(3.24)	(10.4)		(−3.54)	(−1.36)		1.940
USA–	813.71	.076625		−505.29	−266.66		.993
KREA	(1.61)	(10.6)		(−1.24)	(−1.97)		2.050
TWN–	−28.075	.0073928					.939
KREA	(−3.44)	(7.58)					2.393
PHIL–	9.0582	.0029607				−11.576	.894
KREA	(1.29)	(2.15)				(−2.50)	1.067
THAI–	−2.7504	.0005176	1.00100				.962
KREA	(−1.58)	(1.88)	(4.83)				2.263
JPN–	983.35	.10292	.36343	−1223.8		−218.32	.997
PHIL	(2.89)	(4.38)	(2.79)	(−3.86)		(−4.48)	1.785
USA–	734.71	.015308	.33982	−361.79	−260.83		.994
PHIL	(2.76)	(1.02)	(1.44)	(−1.58)	(−1.99)		2.012
TWN–	−12.308	.0042338	.72606		−11.103		.940
PHIL	(−.899)	(1.44)	(1.16)		(−1.32)		1.344
KREA–	2.0986	.0010676		−7.4457			.923
PHIL	(.705)	(5.63)		(−2.93)			2.179
THAI–	8.1990	.0033712			−20.358		.737
PHIL	(.760)	(1.72)			(−1.40)		1.322
JPN–	372.71	.055966	.30930		−429.55		.999
THAI	(4.63)	(4.06)	(1.80)		(−4.47)		2.256
USA–	401.07	.014912	.24435	−137.50	−244.94		.984
THAI	(1.09)	(2.21)	(.964)	(−1.00)	(−1.50)		2.202
TWN–	4.9397	.0058414			−12.502		.986
THAI	(.706)	(10.8)			(−1.90)		1.486
KREA–	.61501	.0015976	.29520		−5.8570		.936
THAI	(.071)	(2.65)	(.962)		(−.588)		1.911
PHIL–	2.1872	.0003950	.47451		−3.6962		.888
THAI	(1.51)	(2.21)	(1.94)		(−2.27)		1.744

* Korean imports ($X\$^{i4}$): 1963–1975. t-ratios are shown in brackets. $Y\$^j = Y^j(PY^j_o/r^j_o)\theta^j$ and $PY\$^j = (PY^j/PY^j_o)/(r^j/r^j_o)$.

The country models of Table 6 are derived after many trials and errors for each equation. Since the prototype model in Table 1 incorporates and allows for the results of such trials and errors, it may be said to be dependent also on the actual country models adopted here. In any case, the actual country models are basically the same as that of the prototype model. However, some minor differences or changes in explanatory variables between them are inevitable judging from signs and significance levels of the estimated coefficients, R^2 and the Durbin-Watson ratios. For example, in the import function of Japan (eq. 7), the price variable is dropped.[11] In the export and import functions of Taiwan (eqs. 6 and 7), the absolute price levels are introduced in place of the relative price levels. In the import function of Korea (eq. 7), the lagged variable is excluded. In the export price function of the Philippines (eq. 9), the world export price is dropped by reason of wrong sign, which seems serious so that the equation must be improved in some way or other. Finally, in the export price function of Thailand (eq. 9), the GDP deflator is not significant enough. Most of these changes and reservations are of minor importance. Our prototype model may be said to summarize well the common and basic features of individual countries. This is true especially for the US case in which the actual country model coincides completely with that of the prototype model.

The actual trade model of Table 7 is also based on the results derived after many trials and errors for each equation. The present model has a merit in estimating individual import functions independently on the country-by-country basis without using such devices as trade share matrix. As a result, we have thirty import functions which are estimated independently as the demand functions of each importing country, *i.e.,* five for each of the six countries. As in the case of country model, the actual trade model (i.e., import functions) shown in Table 7 deviates more or less from that of the prototype model. The deviations occur mainly in relation to the treatment of price variables.[12] The case is quite rare where both of the two relative prices ($PX\$^i/PM\$^j$ and $PX\$^i/PY\$^j$) must be introduced to distinguish between two kinds of price competitiveness in the market of importing country. Actually, the competition of an exporting country with domestic suppliers ($PX\$^i/PY\$^j$) is far more important in explaining import behaviors than the competition of an exporting country with other foreign suppliers ($PX\$^i/PM\$^j$). In some cases, especially for Taiwan, the absolute price

11) Note that the lagged variable is not significant though it is included in the equation. We get similar results also based on the NIS data which is different in the treatment of Ryukyu from the present data.

12) In the case of Korean imports, the lagged variable is mostly of wrong sign or insignificant. Even when it is introduced as an effective explanatory factor (i.e., THAI-KREA), it gives a rather extraordinary estimate of coefficient which is greater than one.

level ($PX\$^{i} \cdot r^{j}$) turns out to be more significant than the relative price levels.[13] The explanatory variables here are selected, of course, based on the signs and t-ratios of coefficient estimates (as well as on R^2 and the Durbin-Watson ratios). The result of selection for price variables in Table 7 seems to reflect, to some extent, the comodity composition of imports in each country, since exports and imports in the present study are treated only in total. The same may be true for the other two explanatory variables ($Y\$^{j}$ and $X\$^{ij}_{-1}$), especially for the latter. For the income variable ($Y\$^{j}$), however, the coefficient estimates are always positive and highly significant with only one exception, *i.e.*, the case of PHIL–USA. The income variable may be said to be the most important and universal factor of explanation in the import functions of any kind for any country.

When the structure is specified for both country and trade models as shown in Tables 6 and 7, we can solve the linked system by the iterative method illustrated in Figure 1 for each year to test the simulatability of the model. The simulatability is usually checked by the dynamic simulation (called final test), which means to solve the model for each year using estimated values (not actual ones) for lagged endogenous variables. The final test in graphical form, which is omitted to save space (See Ezaki [1978], Fig. 2, pp. 20–26), shows that our linked system can simulate the actual economy to a remarkable extent not only for each country but also for the ROW sector and the entire world.[14] The simulatability of the present linked system seems to be adequate enough to be used for various policy simulations. Not to mention, the final test for the unlinked country model is better than that of the linked system because the three world variables are treated as exogenous in the former.

IV Policy Simulations

The model of the present paper contains two policy variables: the government consumption expenditures at constant prices (G^{i}'s) and the exchange rates (r^{i}'s). The dynamic simulations are applied here to the unlinked country model as well as to the linked system for

13) The same was true for the aggregate import function of Taiwan (See Table 6). In the case of Philippine imports from Japan (i.e., JPN-PHIL), both of the relative and absolute prices are introduced because of their good statistical properties, though it is difficult to give good economic interpretations to the equation.

14) In some cases, imports of the country-by-country basis ($X\$^{ij}$) have strong cyclical elements, which are not traced well by the present model. In the case of Korean total exports ($X\$$), the simulated values are negative for 1963 and 1964. This is due to the fact that Korean exports increased extremely rapidly from a quite low level in 1963 or 1964. Note that the number of iterations, which corresponds to the convergence criterion of Figure 1, varies from year to year: 25–40 for 1963–1970, and 50–60 for 1971–1975.

Table 8 Elasticities of Government Expenditures: Average Figures Based on the Dynamic Simulations for 1971–1975*

Country with G changed	Unlinked country model	Linked system JPN	USA	TWN	KREA	PHIL	THAI
		Real GNP or GDP: $\varepsilon(Y^j/G^i)^a$					
JPN	.2959	.3497	.0121	.0451	.0418	.0110	.0244
USA	.5275	.2360	.5828	.2641	.1965	.0554	.1029
TWN	.2153	.0027	.0006	.2268	.0023	.0006	.0012
KREA	.1419	.0020	.0005	.0017	.1459	.0005	.0010
PHIL	.1354	.0001	.0001	−.0006	.0002	.1357	.0002
THAI	.2393	.0012	.0003	.0015	.0010	.0003	.2408
		GNP or GDP deflator: $\varepsilon(PY^j/G^i)^b$					
JPN	.1593	.2445	.0558	.1068	.0787	.1006	.0844
USA	.3329	.2769	.4781	.3165	.2894	.2414	.2008
TWN	.0489	.0035	.0021	.0623	.0035	.0033	.0029
KREA	.1362	.0037	.0025	.0040	.1392	.0035	.0031
PHIL	.0390	.0014	.0011	.0016	.0008	.0366	.0014
THAI	.0399	.0014	.0007	.0016	.0014	.0011	.0399

* Computed at the point where G (real) is changed by $+10\%$ for each country throughout the simulation period, i.e., $\Delta G_t^i/G_t^i=0.1\binom{i=\text{JPN},\ldots,\text{THAI}}{t=1971,\ldots,1975}$. In the case of unlinked country model, change in G in certain country does not influence economic activities of other countries so that only the own elasticities (i.e., diagonal elements) are shown above.

[a] $\varepsilon(Y^j/G^i)\equiv(\Delta\bar{Y}^j/\Delta\bar{G}^i)\cdot(\bar{G}^i/\bar{Y}^j)$,

where $\bar{G}^i$ = actual G^i, averaged for 1971–75 (i.e., $(1/5)\Sigma G_t^i$),

$\Delta\bar{G}^i$ = change in $\bar{G}^i$,

$\bar{Y}^j$ = simulated Y^j under unchanged G^i, averaged for 1971–75,

$\Delta\bar{Y}^j+\bar{Y}^j$ = simulated Y^j under changed G^i, averaged for 1971–75.

[b] $\varepsilon(PY^j/G^i)\equiv(\Delta\overline{PY}^j/\Delta\bar{G}^i)\cdot(\bar{G}^i/\overline{PY}^j)$,

where $\overline{PY}^j$ = (simulated $PY^j\cdot Y^j$, averaged)/(simulated Y^j, averaged), under unchanged G,

$\Delta\overline{PY}^j+\overline{PY}^j$ = (simulated $PY^j\cdot Y^j$, averaged)/(simulated Y^j, averaged), under changed G.

the period 1971–1975 to quantify the effects of the changes in these policy variables in that period.[15] The results are summarized in terms of average elasticities in Tables 8 and 9 for only two variables: GNP or GDP (Y) and its deflator (PY). The elasticity is a convenient measure to see the effects on prices, but the multiplier may be better if we want to compare the effects on quantities or values between countries. Tables 9 and 10 summarize the results of simulation in terms of average multipliers for several quantity or value variables. Definitions and computational procedures are explained in detail in each of the four tables. However, it should be stressed in the case of multipliers that the measuring unit for quantities or values in

15) We get similar results even when the simulation analyses are applied for the period 1966–1970.

Table 9 Elasticities of Exchange Rates: Average Figures Based on the Dynamic Simulations for 1971–1975*

Country with r changed	Unlinked country model	Linked system JPN	USA	TWN	KREA	PHIL	THAI
		Real GNP or GDP: $\varepsilon(Y^j/r^i)^a$					
JPN	.1369	.1304	−.0194	.1195	−.0210	.0032	−.0404
USA	.0604	−.1014	.0241	.0058	−.0981	−.0272	−.0710
TWN	.3029	.0005	−.0006	.3203	−.0002	−.0000	−.0012
KREA	.1526	−.0005	−.0015	.0095	.1476	−.0008	−.0017
PHIL	.0366	.0047	.0007	.0077	.0037	.0314	.0015
THAI	.1274	.0006	.0000	.0013	.0004	.0001	.1235
		GNP or GDP deflator: $\varepsilon(PY^j/r^i)^b$					
JPN	.4618	.2866	−.1772	−.3032	−.1365	−.3537	−.2958
USA	.3981	−.2443	.2004	−.3080	−.2003	−.3173	−.2627
TWN	.8150	−.0061	−.0067	.8113	−.0033	−.0105	−.0099
KREA	.3879	−.0185	−.0164	−.0209	.3785	−.0233	−.0208
PHIL	.6894	.0029	.0006	.0030	.0044	.7392	.0010
THAI	.6066	−.0003	−.0004	−.0007	.0002	−.0009	.6142

* Computed at the point where r is changed by $+10\%$ (i.e., devaluation) for each country throughout the simulation period, i.e.,

$$\Delta r_t^i / r_t^i = 0.1 \quad (i = \text{JPN}, \ldots, \text{THAI}; \; t = 1971, \ldots, 1975).$$

Note that the 10% devaluation of US exchange rate (from 1.0 to 1.1) means the devaluation of US dollars to every country. When r is changed for each country by -10% (i.e., appreciation), almost the similar results (different by 10–20% in absolute value) are obtained with the signs almost completely opposite. In the case of unlinked country model, again, change in r in certain country does not affect economic activities of other countries.

[a] $\varepsilon(Y^j/r^i) \equiv (\Delta \bar{Y}^j / \Delta \bar{r}^i) \cdot (\bar{r}^i / \bar{Y}^j)$. See footnote a to Table 8.

[b] $\varepsilon(PY^j/r^i) \equiv (\Delta \overline{PY}^j / \Delta \bar{r}^i) \cdot (\bar{r}^i / \overline{PY}^j)$. See footnote b to Table 8.

each country is standardized (*i.e.*, converted into US dollars) to make the international comparison direct. Note that, in the case of unlinked country model, the change in G or r in a certain country does not affect economic activities of other countries by the properites of the model. In Tables 8∼11, therefore, are shown only the own elasticities or own multipliers for the unlinked country model, which must be compared with the diagonal elements of elasticity or multiplier matrices for the linked system.

Let us begin with the case where the government consumption expenditures at constant prices are changed in each of the six countries respectively. From the simulation results summarized in Tables 8 and 10, we can derive basic facts and implications which underlie the interdependent relations among countries, and clarify the advantages and merits of the linked system compared to the unlinked country model.

First, the six countries are mutually

Table 10 Multipliers of Government Expenditures: Average Figures Based on the Dynamic Simulations for 1971–1975*

Country with G changed	Unlinked country model	Linked system JPN	USA	TWN	KREA	PHIL	THAI
		Real GNP or GDP: $\bar{\mu}(Y\$^j/G\$^i)^a$					
JPN	3.5480	4.1295	.6530	.0159	.0239	.0046	.0095
USA	2.5511	.2487	2.8153	.0083	.0100	.0021	.0036
TWN	1.3806	.5612	.5908	1.4058	.0229	.0047	.0084
KREA	1.4569	.4284	.5231	.0104	1.4811	.0040	.0072
PHIL	1.4064	.0391	.1666	−.0052	.0026	1.4130	.0021
THAI	2.0708	.3216	.3086	.0117	.0129	.0026	2.0783
		Commodity exports in constant US$: $\bar{\mu}(X\$^j/G\$^i)^b$					
JPN	−.0512	.1190	.2086	.0045	.0149	.0036	.0023
USA	−.0171	.0737	.0777	.0043	.0066	.0018	.0012
TWN	−.0333	.1631	.2055	−.0272	.0149	.0040	.0025
KREA	−.0710	.1207	.1486	.0026	−.0579	.0032	.0018
PHIL	−.0614	.0125	.0101	−.0074	.0008	−.0559	−.0001
THAI	−.0129	.0951	.1224	.0065	.0087	.0023	−.0110
		Commodity imports in constant US$: $\bar{\mu}(M\$^j/G\$^i)^c$					
JPN	.3289	.3822	−.0472	.0007	.0068	.0003	−.0004
USA	.1663	.0228	.1580	.0020	.0032	.0002	.0002
TWN	.7389	.0515	−.0263	.7389	.0071	.0005	.0001
KREA	.5179	.0396	−.0488	.0002	.5241	.0003	−.0002
PHIL	.2854	.0037	−.0557	−.0061	.0000	.2861	−.0007
THAI	.3886	.0294	−.0048	.0035	.0042	.0003	.3888
		Commodity exports in current US$: $\bar{\mu}(PX\$^jX\$^j/G\$^i)^d$					
JPN	.0271	.4593	.6927	.0255	.0354	.0167	.0144
USA	.0105	.1587	.2364	.0113	.0124	.0052	.0044
TWN	−.0040	.3642	.5402	.0204	.0294	.0125	.0109
KREA	.0042	.3082	.4910	.0168	.0293	.0117	.0102
PHIL	.0133	.0991	.2081	−.0027	.0080	.0138	.0046
THAI	.0035	.1952	.2715	.0150	.0154	.0062	.0083
		Commodity imports in current US$: $\bar{\mu}(PM\$^jM\$^j/G\$^i)^e$					
JPN	.6075	.9377	.3587	.0244	.0412	.0166	.0128
USA	.2836	.0981	.3625	.0091	.0115	.0038	.0031
TWN	1.1652	.2466	.2395	1.1899	.0285	.0101	.0084
KREA	.8016	.2667	.2660	.0160	.8259	.0106	.0085
PHIL	.4781	.1458	.1508	.0009	.0133	.4607	.0048
THAI	.6350	.1180	.0966	.0120	.0134	.0042	.6238

* Computed at the point where G (real) is changed by $+10\%$ for each country throughout the simulation period. See footnotes to Table 8.

[a] $\bar{\mu}(Y\$^j/G\$^i) \equiv \varepsilon(Y^j/G^i)\cdot(\overline{Y\$^j}/\overline{G\$^i}) = \Delta\overline{Y\$^j}/\Delta\overline{G\$^j}$,

where $\overline{Y\$^j} = \bar{Y}^j(PY_0^j/r_0^j)\theta^j$ (i.e., in millions of constant 1970 US$),

$\overline{G\$^i} = \bar{G}^i(PG_0^i/r_0^i)\theta^i$ (i.e., in millions of constant 1970 US$),

$\varepsilon(Y^j/G^i) = (\Delta\bar{Y}^j/\Delta\bar{G}^i)\cdot(\bar{G}^i/\bar{Y}^j) = (\Delta\overline{Y\$^j}/\Delta\overline{G\$^i})\cdot(G\$^i/Y\$^j)$.

[b] $\bar{\mu}(X\$^j/G\$^i) \equiv \varepsilon(X\$^j/G^i)\cdot(\overline{X\$^j}/\overline{G\$^i}) = \Delta\overline{X\$^j}/\Delta\overline{G\$^i}$).

[c] $\bar{\mu}(M\$^j/G\$^i) \equiv \varepsilon(M\$^j/G^i)\cdot(\overline{M\$^i}/\overline{G\$^i}) = \Delta\overline{M\$^j}/\Delta\overline{G\$^i}$.

[d] $\bar{\mu}(PX\$^jX\$^j/G\$^i) \equiv \varepsilon(PX\$^jX\$^j/G^i)\cdot(\overline{PX\$^jX\$^j}/\overline{G\$^i}) = \Delta(\overline{PX\$^jX\$^j})/\Delta\overline{G\$^i}$.

[e] $\bar{\mu}(PM\$^jM\$^j/G\$^i) \equiv \varepsilon(PM\$^jM\$^j/G^i)\cdot(\overline{PM\$^jM\$^j}/\overline{G\$^i}) = \Delta(\overline{PM\$^jM\$^j})/\Delta\overline{G\$^i}$.

Table 11 Multipliers of Exchange Rates: Average Figures Based on the Dynamic Simulations for 1971–1975*

Country with r changed	Unlinked country model	Linked system JPN	USA	TWN	KREA	PHIL	THAI
		Real GNP or GDP: $\bar{\mu}(Y\$^j/r^i)/100^a$					
JPN	326.52	306.91	−208.78	8.38	−2.39	0.26	−3.14
USA	652.09	−238.48	259.71	0.41	−11.17	−2.28	−5.52
TWN	21.98	1.10	−6.31	22.46	−0.03	−0.00	−0.09
KREA	17.55	−1.05	−15.90	0.67	16.80	−0.07	−0.21
PHIL	3.07	10.95	7.61	0.54	0.42	2.62	0.12
THAI	9.93	1.39	0.41	0.09	0.05	0.01	9.59
		Commodity exports in constant US$: $\bar{\mu}(X\$^j/r^i)/100^b$					
JPN	84.10	82.65	10.92	11.86	0.26	1.02	0.78
USA	80.31	−63.51	8.87	5.57	−5.94	−1.39	−0.58
TWN	3.73	0.60	1.24	4.14	0.05	0.02	0.03
KREA	8.38	0.10	0.96	0.86	8.07	−0.02	0.04
PHIL	1.41	3.18	4.21	0.39	0.30	1.00	0.06
THAI	0.39	0.43	0.59	0.09	0.04	0.01	0.37
		Commodity imports in constant US$: $\bar{\mu}(M\$^j/r^i)/100^c$					
JPN	30.41	28.45	78.73	9.62	0.69	0.70	1.55
USA	−141.58	−22.13	−78.08	5.32	−2.61	0.15	0.81
TWN	−1.28	0.09	2.99	−0.94	0.03	0.02	0.05
KREA	3.39	−0.11	6.11	0.67	3.23	0.02	0.09
PHIL	−0.57	1.01	1.05	0.26	0.15	−0.65	0.03
THAI	−2.02	0.13	0.32	0.06	0.02	0.00	−2.01
		Commodity exports in current US$: $\bar{\mu}(PX\$^jX\$^j/r^i)/100^d$					
JPN	−34.34	−120.94	−229.16	6.19	−8.32	−6.36	−5.34
USA	−42.07	−201.27	−397.71	−4.05	−17.00	−8.98	−7.80
TWN	0.30	−2.27	−7.01	0.91	−0.24	−0.19	−0.17
KREA	0.52	−8.53	−20.59	0.37	−0.27	−0.53	−0.48
PHIL	−0.29	5.52	6.69	0.65	0.45	0.17	0.13
THAI	−0.07	0.43	0.14	0.10	0.03	−0.00	−0.04
		Commodity imports in current US$: $\bar{\mu}(PM\$^jM\$^j/r^i)/100^e$					
JPN	53.34	−85.02	−186.59	−2.06	−20.98	−10.97	−7.70
USA	−221.93	−200.50	−407.19	−7.31	−22.98	−10.33	−7.51
TWN	−1.73	−5.31	−6.99	−1.39	−0.57	−0.33	−0.25
KREA	5.66	−15.90	−18.59	−0.09	4.44	−0.74	−0.55
PHIL	−0.81	2.07	1.79	0.46	0.29	0.60	0.06
THAI	−2.78	−0.29	−0.36	0.05	−0.01	−0.02	−2.57

* Computed at the point where r is changed by $+10\%$ (i.e., devaluation) for each country throughout the simulation period. See footnotes to Table 9. Note that multipliers are all divided by 100 so that they indicate the effects (in million $) of the 1% change in r.

[a] $\bar{\mu}(Y\$^j/r^i) \equiv \bar{\varepsilon}(Y^j/r^i)\cdot\overline{Y\$^j} = \Delta\overline{Y\$^j}/(\Delta\bar{r}^i/\bar{r}^i)$ (in millions of constant 1970 US$)

[b] $\bar{\mu}(X\$^j/r^i) \equiv \bar{\varepsilon}(X\$^j/r^i)\cdot\overline{X\$^j} = \Delta\overline{X\$^j}/(\Delta\bar{r}^i/\bar{r}^i$ (in millions of constant 1970 US$)

[c] $\bar{\mu}(M\$^j/r^i) \equiv \bar{\varepsilon}(M\$^j/r^i)\cdot\overline{M\$^j} = \Delta\overline{M\$^j}/(\Delta\bar{r}^i/\bar{r}^i)$ (in millions of constant 1970 US$)

[d] $\bar{\mu}(PX\$^jX\$^j/r^i) \equiv \bar{\varepsilon}(PX\$^jX\$^j/r^i)\cdot\overline{PX\$^j}\overline{X\$^j} = \Delta(\overline{PX\$^j}\overline{X\$^j})/(\Delta\bar{r}^i/\bar{r}^i)$ (in millions of current US$)

[e] $\bar{\mu}(PM\$^jM\$^j/r^i) \equiv \bar{\varepsilon}(PM\$^jM\$^j/r^i)\cdot\overline{PM\$^j}\overline{M\$^j} = \Delta(\overline{PM\$^j}\overline{M\$^j})/(\Delta\bar{r}^i/\bar{r}^i)$ (in millions of current US$)

dependent more or less in the positive direction since the effects on real GNP or GDP in the linked system are all positive except one: PHIL–THAI (Tables 8 and 10: real GNP or GDP). The six countries are, so to speak, in a state of co-prosperity in the sense that economic growth due to the increase in government expenditures in some country spreads over the other countries mainly through their export increases (Table 10: commodity exports in constant US$).

Second, the positive interdependency among countries with respect to government expenditures is different in degree from country to country. As is expected, the interdependency within the four countries of East and Southeast Asia is very weak relative to their dependency on Japan and the United Staes, especially on the latter, in terms of elasticities (Table 8: real GNP or GDP).[16] This is partly due to the fact that the elasticity reflects the absolute economic scale of each country. Also in terms of multipliers, the four Asian countries can be said to have strong import dependencies on Japan and U.S.A., because the multiplier effects of the former to the latter are always far greater than those of the latter to the former (Table 10: real GNP or GDP and commodity exports in constant US$). This means that Japan and U.S.A. can realize far greater increases in real GNP than the four countries in East and Southeast Asia when the government expenditures are increased by the same amount in the respective counterpart countries. Furthermore, in terms of both elasticities and multipliers, Taiwan and Korea are under closer relations with Japan and the United States than the Philippines and Thailand (Tables 8 and 10: real GNP or GDP).

Third, the unlinked country model always underestimates the quantity effects of government expenditures on total production and exports due to the fact that it neglects the aspect of positive interdependency or co-prosperity among countries through trade (Table 8: real GNP or GDP, and Table 10: real GNP or GDP and commodity exports in constant US$).[17] The same is true for the price effects of government expenditures. That is to say, the unlinked country model underestimates, with only a few exceptions, the inflationary tendencies caused by the expansion of government

16) Note that, when the off-diagonal elements are divided by the diagonal elements in the row-wise direction in Table 8 (real GNP or GDP), we get another kind of GNP elasticities (which are shown only for Japan and U.S.A. below):

	JPN	USA	TWN	KREA
JPN	1.0000	.0346	.1290	.1195
USA	.4049	1.0000	.4532	.3372

	PHIL	THAI
JPN	.0315	.0698
USA	.0951	.1766

In the case of USA-KREA, for example, the above figure (.3372) indicates that Korean real GDP increases by .3372% when US real GNP increases by 1% as a result of expanding its government expenditures.

17) In the case of import quantities (Table 10: commodity imports in constant *US*$), the overestimation is observed for U.S.A. due to its negative correlations with other economies (column figures), and also for Taiwan though to a very small extent.

expenditures (Table 8: GNP or GDP deflator, and Table 10: commodity exports in current US$). This underestimation is conspicuous especially in the case of export quantities, where the signs of multipliers are completely opposite for Japan and U.S.A. between the unlinked country model and the linked system (Table 10: commodity exports in constant US$). Generally speaking, the degree of underestimation is not so large for the four countries in East and Soubeast Asia as for Japan and the United States. This indicates that even the country model without linkage will not provide very much misleading results for these relatively small countries, especially if their trade relations with big economies such as Japan and U.S.A. are explicitly introduced in the model. The advantages and merits of the linked system will obviously be greater in the analysis of big economies which occupy significant positions in the world market.

Let us next consider the case where the exchange rate is changed in each of the six countries respectively. Though the world experienced a drastic change in monetary system during our simulation period (1971–1975) from the fixed exchange rate system to the floating one, the present analysis seems to be useful to get a rough idea on the quantitative effects of exchange rate changes. Note that the simulation results summarized in Tables 9 and 11 correspond to the case of devaluation. The results are, however, symmetrical in the sense that we get, also for the case of appreciation, similar results (different by 10–20% in absolute value) with the signs almost completely reversed. It is difficult, unlike the previous case of government expenditures, to derive general facts and implications from Tables 9 and 11, so that rather specific aspects of exchange rate changes are stressed only on the following two scores.

First, the exchange rate devaluation in some country has positive effects on total production (real GNP or GDP), general price level (GNP or GDP deflator) and export quantities (commodity exports in constant US$) of the country with the exchange rate changed, but its effects on other economies are not uniform, positive in some cases and negative in others, depending on the specific trade structure of the linked system. In other words, a positive interdependency (or a state of co-prosperity) between countries cannot be observed in the present case of exchange rate changes. It is of particular interest to see that the devaluation (or appreciation) in some country is not always unfavorable against (or favorable for) other economies.

Second, the Japanese case is useful to illustrate the basic nature of the linked system as well as its relevance to the actual economy. According to the results shown in Tables 9 and 11, the yen devaluation causes positive increases in the three *quantity* variables of Japan: real GNP, and commodity exports and imports in constant US$. This is an expected result, though the quantity of imports needs not be affected positively by the exchange rate devaluation as is seen from the diagonal elements corresponding to other countries. On the other hand, the yen devaluation causes the decrease in the two *value* variables of Japan: commodity exports and commodity imports in current US$. It should be noted that the signs above are opposite between quantities and values for the Japanese exports and imports. The reason is that after allowing for the world equilibrium conditions under the yen devaluation, the increases in quantities are relatively smaller than the decreases in prices in terms of US dollars for the exports and imports of Japan.[18] Furthermore, in case of the yen devaluation, the trade balance of merchandise, f.o.b. which is defined as the difference between commodity exports and commodity imports in current US$ (Table 11) is negative for Japan, negative for U.S.A., and positive for the remaining four countries (i.e., −35.92, −142.57, 8.25, 12.66, 4.61 and 2.36 million US$, respectively, in the case of 1% devaluation in yen). These results and implications are completely reversed in the case where the yen is appreciated. In other words, the yen appreciation brings about various depressing effects on the Japanese economy (*i.e.*, real GNP down, real exports and imports down, price level down, *etc.*). At the same time, it causes trade surpluses in Japan and U.S.A., on the one hand, and trade deficits in Taiwan, Korea, Philippines and Thailand, on the other. Currently (around September 1978 when the present paper was drafted), Japan is appreciating the yen drastically without causing deterioration in trade balance under a rather depressed phase of domestic economy. The actual economy is, of course, a complex phenomenon with various factors mixed and entangled. Yet, our simulation results seem to coincide, at least in the short-run, with the current situation of the Japanese economy.[19]

It is possible to derive many other facts and implications from Tables 9 and 11 as well as from Tables 8 and 10, especially in relation to the numerical results on each variable of each country. They are, however, not discussed here and left to be investigated by those who are interested in rather specific aspects of the present linked system.

V Concluding Remarks

Even the country model without linkage will not provide very misleading results for the small countries whose positions in the world market are rela-

18) Roughly speaking, the yen devaluation decreases first *PX$* and then *PW$* and *PM$* in the process of price changes, while it increases first *X$*, then *Y* and finally *M$* in the process of quantity changes. This is, of course, only an approximate interpretation of the simultaneously determined system with particular reference to the Japanese economy.

19) Many economists expect the deterioration of Japanese trade balance in the near future, which may be considered as a serious structural change from the point of view of the present model, because we get essentially similar results even in the case where the yen is appreciated by 50% (i.e., $\Delta r/r=0.5$) throughout the simulation period.

tively minor, provided that the correct data are given to those countries concerning the world variables such as total world trade, world export prices, import prices and so on. For most of the East and Southeast Asian countries, therefore, their individual national models, when supplemented by their trade relations with big economies such as Japan and U.S.A., can be used as the first and effective approximation to the linked system. The forecasting performance based on them will not be inferior to that of the linked system as far as the correct data are provided in the forecasting period not only for the world but also for their important trading partners. This is, of course, not to say that the linked model is unnecessary for relatively small countries. The analysis and forecasting of world market itself cannot be made properly without introducing those small countries in some way or other.

The present pilot model for linkage, though simple, seems to be useful by itself to analyze the highly aggregated aspects of national economies as well as of world markets. However, various extensions and modifications may be necessary to make the present model more practical and more realistic. First, the country coverage should be extended and widened from the present four countries in East and Southeast Asia (in addition to Japan and U.S.A.) to all countries in the same region, or all countries in the Pacific basin, or all countries in the ESCAP region, and so on. Second, the model for the rest of the world (ROW) sector should be elaborated in view of its weight in the world market, especially when the country coverage is not extensive. Third, the supply side should be explicitly allowed for especially in the country model, introducing production functions, savings equations, *etc.*, which will make it possible to introduce capital transactions between countries into the linked system. Fourth, exports and imports should be disaggregated by commodities according to, say, the SITC numbers. The extensions and modifications of the present model along these lines will be the direction of the author's subsequent researches.

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