An International Input-Output Analysis on the Effects of Free Trade Agreements in Asia*

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I. Introduction

In recent years, bilateral/regional free trade agreements (FTAs) have become popular whereas the establishment of the multilateral free trade system under the World Trade Organization has stagnated. Viewing several examples in Asia, the free trade agreement between Japan and Singapore was activated in November, 2002, and negotiations/studies are currently underway between Japan and South Korea, Japan and the Association of South East Asian Nations (ASEAN), South Korea and Singapore, China and the ASEAN, Taiwan and Singapore, and Singapore and the United States.[3] Since most Asian economies are highly trade-dependent small open economies, FTAs in Asia may have both domestic and international effects.

Focusing on these movements, several economists have analyzed issues on FTAs by applying multi-sectoral multi-country models. Yamazawa (2001), Nakajima (2002), Tsutsumi and Kiyota (2002), and Urata and Kiyota (2003) are examples for applications of computable general equilibrium (CGE) models. All of them applied the GTAP (Global Trade Analysis Project) model which is based on the GTAP Database and found that FTAs would provide overall positive effects on the member economies of FTAs.[4] Differed from these analyses, in this paper, we have constructed an international input-output model which is based on the 78 sectors version of the Asian International Input-Output Table 1990 compiled by the Institute of Developing Economies (IDE [1998]).[5] Since this Asian international input-output table covers 10 economies (Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, South Korea, Japan, and the United States), we have insured the same country coverage in our international input-output system.

By applying this model to several simulation scenarios, this paper analyzes the effects of FTAs in Asia on the 10 economies at the sectoral level.

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[3] Kawai (2003) summarized FTAs in East Asia and confirmed the importance of FTAs in the context of national securities in the region.

[4] As for the GTAP Database and model, see Hertel (1997).

[5] A layout of the Asian International Input-Output Table is presented in Table 1.

II. The Model

In this section, the structure of our international input-output model is explained.[6] The model is essentially based on the Leontief input-output model, which determines sectoral output by exogenously given final demands. The model consists two main blocks: determinations of sectoral output and prices.[7]

Determination of Sectoral Output

Using a balance equation of an international input-output table, we explain sectoral output as follows:

$$\sum_j \sum_k X^k_{ij(h)} + F_{i(h)} = X_{i(h)}, \qquad i = 1, 2, \cdots, M; h = 1, 2, \cdots, N, \tag{1}$$

where $X^k_{ij(h)}$ is intermediate inputs of the *i*th commodity imported from the *h*th economy in the *j*th sector of the *k*th economy, $F_{i(h)}$ is final demands in the *i*th sector of the *h*th economy (given in this model), and $X_{i(h)}$ is sectoral output in the *i*th sector of the *h*th economy.[8] Then, we explain the determination of intermediate input. First, technical coefficient is defined. Following the Leontief input-output model, we formulate intermediate input as:

$$X^k_{ij} = a^k_{ij} X^k_j, \tag{2}$$

where X^k_{ij} is intermediate input of the *i*th commodity in the *j*th sector of the *k*th economy, a^k_{ij} is the technical coefficient of the *i*th commodity in the *j*th sector of the *k*th economy, and X^k_j is control totals in the *j*th sector of the *k*th economy. Rearranging equation (2) gives technical

[6] The formulation of an international input-output model presented here is not unique. For another formulation, see Torii, Shim, and Akiyama (1989).

[7] For further explanation on this model, see Kosaka (1994).

[8] Although we do not endogenize final demands in this paper, final demands can be endogenized by interlinking an international input-output model and macroeconometric models. As for a formulation for this linkage, see the Appendix.

coefficient as:

$$a_{ij}^{k} = \frac{\sum_{h} X_{ij(h)}^{k}}{X_{j}^{k}}. \tag{3}$$

Then, in order to analyze international trade pattern, we distinguish between inputs of domestic and imported goods. Applying the Hickman and Lau (1973) trade linkage model, we allocate a share of each economy in total intermediate input as follows:

$$\frac{X_{ij(h)}^{k}}{X_{ij}^{k}} = m_{ij(h)}^{k*}\left[\frac{\left(1+t_{i}^{k}\right)PX_{ij(h)}^{k}}{\sum_{q\neq h} m_{ij(q)}^{k*}\left(1+t_{i}^{k}\right)PX_{ij(q)}^{k}}\right]^{-s_{(ijk)}}, \tag{4}$$

where $m_{ij(h)}^{k*}$ is the base year share of the *i*th commodity imported from the *h*th economy in the *j*th sector of the *k*th economy, $PX_{ij(h)}^{k}$ is export prices of the *i*th commodity of the *h*th economy in the *j*th sector of the *k*th economy, t_{i}^{k} is the tariff rate of the *i*th commodity of the *k*th economy, $s_{(ijk)}$ is the elasticity of substitution of the *i*th commodity in the *j*th sector of the *k*th economy, and *q* is competitors. Thus, intermediate input is determined by the two steps. At the first step, the total intermediate input of the *i*th commodity in the *j*th sector of the *k*th economy is determined by equation (2). However, technical coefficient in equation (2) is derived from the intermediate input, i.e., input of the mixture of domestic and imported goods. Hence, at the second step, in order to determine the domestic and imported goods' shares, the modified Hickman-Lau trade linkage model is applied as in equation (4).

Determination of Sectoral Prices

Sectoral prices are also explained endogenously in this international input-output model. Sectoral prices are determined by another identity of an international input-output table: that is,

$$P_{j}^{k}X_{j}^{k} = V_{j}^{k} + \sum_{i}\sum_{h} PX_{ij(h)}^{k}X_{ij(h)}^{k} + \left(C_{j1}^{k} + C_{j0}^{k}\right), \tag{5}$$

where P_j^k is the price level in the *j*th sector of the *k*th economy, V_j^k is the value added in the *j*th sector of the *k*th economy, C_{j1}^k is tariffs on imports of the *i*th commodity in the *j*th sector of the *k*th economy, and C_{j0}^k is the others in the *j*th sector of the *k*th economy.[9] Dividing equation (5) by X_j^k yields the price equation as:

$$\begin{aligned} P_j^k &= \frac{V_j^k}{X_j^k} + \frac{\sum_i \sum_h PX_{ij(h)}^k X_{ij(h)}^k}{X_j^k} + \frac{\left(C_{j1}^k + C_{j0}^k\right)}{X_j^k}, \\ &= v_j^k + \frac{\sum_i \sum_h PX_{ij(h)}^k X_{ij(h)}^k}{X_j^k} + \left(\frac{C_{j1}^k}{X_j^k} + c_{j0}^k\right), \end{aligned} \tag{6}$$

where v_j^k is value added coefficient in the *j*th sector of the *k*th economy. The prices level in the *j*th sector of the *k*th economy in the base year is unity. Then, we explain the components of the price equation. First, the value added is explained. The value added can be divided into wages and the others factors. Since the wage rate multiplied by employment is wages, the value added can be formulated as follows:

$$V_j^k = W_j^k + V_{j0}^k = w_j^k L_j^k + V_{j0}^k, \tag{7}$$

where W_j^k is wages in the *j*th sector of the *k*th economy, V_{j0}^k is the value added (except for wages) in the *j*th sector of the *k*th economy, w_j^k is the wage rate in the *j*th sector of the *k*th economy, and L_j^k is employment in the *j*th sector of the *k*th economy. In this model, we assume that the sectoral wage rate is a function of the wage rates at the aggregated level. The formulation of the sectoral wage rate is as follows:

$$w_j^k = f\left(w^k\right), \tag{8}$$

[9] The main component of the other factor is the international freight and insurance.

where w^k is the wage rate at the aggregated level of the *k*th economy. The sectoral employment is determined by the Ozaki (1979) employment function, which is formulated as follows:

$$L_j^k = \alpha_j^k \left(X_j^k\right)^{\beta_j^k}, \qquad \beta_j^k < 1, \tag{9}$$

where α_j^k is the employment coefficient in the *j*th sector of the *k*th economy and β_j^k is the elasticity of labor input in the *j*th sector of the *k*th economy. Economies of scale are taken into account in this model thorough the elasticity of labor input. Dividing equation (7) by X_j^k gives value added coefficient as:

$$v_j^k = \frac{V_j^k}{X_j^k} = \frac{w_j^k L_j^k}{X_j^k} + \frac{V_{j0}^k}{X_j^k} = \frac{w_j^k L_j^k}{X_j^k} + v_{j0}^k, \tag{10}$$

where v_{j0}^k is the ratio of the value added (except for wages) to X_j^k.

Regarding the factors except for the value added, we can divide them into tariffs and the other factors. Tariffs can be formulated as:

$$C_{j1}^k = \sum_{h \neq k} \sum_i t_i^k P X_{ij(h)}^k X_{ij(h)}^k. \tag{11}$$

As for the other factors, their base year ratio (to X_j^k) is assumed to be fixed. Thus, the other factors are explained as:

$$C_{j0}^k = c_{j0}^k X_j^k, \tag{12}$$

where c_{j0}^k is the base year ratio of the other factors to X_j^k.

Finally, export prices are explained. In this model, the formulation of export prices depends on the existence of export subsidies. Export prices of the *i*th commodity of the *h*th economy in the *j*th sector of the *k*th economy with export subsidies are formulated as:

$$PX^{k}_{ij(h)} = \left(1 - \tau^{h}_{i}\right) P^{h}_{i}, \tag{13}$$

where τ^{h}_{i} is the export subsidy of the *i*th commodity of the *h*th economy and P^{h}_{i} is the price level in the *i*th sector of the *h*th economy. By contrast, the export prices without export subsidies can be written as:

$$PX^{k}_{ij(h)} = P^{h}_{i}. \tag{14}$$

Appendix

Although final demands are usually treated as exogenous variables in an input-output model, we can endogenize them by linking an international input-output model and macroeconometric models. As for final demands, we divide them into those of economies composing an international input-output table and of the rest of the world (ROW). Since macroeconometric models explain final demands at the aggregated level, we need to allocate them at the sectoral level. In order to obtain sectoral final demands, the same approach in intermediate input, the modified Hickman-Lau trade linkage model, can be applied. Hence, final demands in an international input-output model can be written as:

$$\begin{aligned} F &= \sum_{k} F^{k} + F^{o}, \\ &= \sum_{k} H^{k} g^{k} + F^{o}, \end{aligned} \tag{A1}$$

where F is final demands, F^{k} is final demands of the *k*th economy, F^{o} is final demands of the ROW (assumed to be given), H^{k} is a converter matrix of the final demands of the *k*th economy $\left[H^{k} = \left(f^{k}_{ig}\right) = \left(\sum_{q \neq k} P^{q}_{i} \Big/ P^{k}_{i} \right)^{sf_{(igk)}} f^{k*}_{ig} \right]$, g^{k} is final demands of the *k*th economy explained by its macroeconometric model, P^{k}_{i} is the price level in the *i*th sector of the *k*th economy, P^{q}_{i} is the price level in the *i*th sector of the *q*th economy, $sf_{(igk)}$ is elasticity of

substitution of the final demands in the *i*th sector of the *k*th economy, and f_{ig}^{k*} is the base year share of final demands in the *i*th sector of the *k*th economy.

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Table 1 Layout of the Asian International Input-Output Table

		Intermediate Demand (A)										Final Demand (F)										Export (L)							
		I	M	P	S	T	C	N	K	J	U	I	M	P	S	T	C	N	K	J	U	LH	LE	LF	LG	LL	LW	Q	X
Intermediate Input (A)	Indonesia (I)	A^{II}	A^{IM}	A^{IP}	A^{IS}	A^{IT}	A^{IC}	A^{IN}	A^{IK}	A^{IJ}	A^{IU}	F^{II}	F^{IM}	F^{IP}	F^{IS}	F^{IT}	F^{IC}	F^{IN}	F^{IK}	F^{IJ}	F^{IU}	LH^{I}	LE^{I}	LF^{I}	LG^{I}	LL^{I}	LW^{I}	Q^{I}	X^{I}
	Malaysia (M)	A^{MI}	A^{MM}	A^{MP}	A^{MS}	A^{MT}	A^{MC}	A^{MN}	A^{MK}	A^{MJ}	A^{MU}	F^{MI}	F^{MM}	F^{MP}	F^{MS}	F^{MT}	F^{MC}	F^{MN}	F^{MK}	F^{MJ}	F^{MU}	LH^{M}	LE^{M}	LF^{M}	LG^{M}	LL^{M}	LW^{M}	Q^{M}	X^{M}
	Philippines (P)	A^{PI}	A^{PM}	A^{PP}	A^{PS}	A^{PT}	A^{PC}	A^{PN}	A^{PK}	A^{PJ}	A^{PU}	F^{PI}	F^{PM}	F^{PP}	F^{PS}	F^{PT}	F^{PC}	F^{PN}	F^{PK}	F^{PJ}	F^{PU}	LH^{P}	LE^{P}	LF^{P}	LG^{P}	LL^{P}	LW^{P}	Q^{P}	X^{P}
	Singapore (S)	A^{SI}	A^{SM}	A^{SP}	A^{SS}	A^{ST}	A^{SC}	A^{SN}	A^{SK}	A^{SJ}	A^{SU}	F^{SI}	F^{SM}	F^{SP}	F^{SS}	F^{ST}	F^{SC}	F^{SN}	F^{SK}	F^{SJ}	F^{SU}	LH^{S}	LE^{S}	LF^{S}	LG^{S}	LL^{S}	LW^{S}	Q^{S}	X^{S}
	Thailand (T)	A^{TI}	A^{TM}	A^{TP}	A^{TS}	A^{TT}	A^{TC}	A^{TN}	A^{TK}	A^{TJ}	A^{TU}	F^{TI}	F^{TM}	F^{TP}	F^{TS}	F^{TT}	F^{TC}	F^{TN}	F^{TK}	F^{TJ}	F^{TU}	LH^{T}	LE^{T}	LF^{T}	LG^{T}	LL^{T}	LW^{T}	Q^{T}	X^{T}
	China (C)	A^{CI}	A^{CM}	A^{CP}	A^{CS}	A^{CT}	A^{CC}	A^{CN}	A^{CK}	A^{CJ}	A^{CU}	F^{CI}	F^{CM}	F^{CP}	F^{CS}	F^{CT}	F^{CC}	F^{CN}	F^{CK}	F^{CJ}	F^{CU}	LH^{C}	LE^{C}	LF^{C}	LG^{C}	LL^{C}	LW^{C}	Q^{C}	X^{C}
	Taiwan (N)	A^{NI}	A^{NM}	A^{NP}	A^{NS}	A^{NT}	A^{NC}	A^{NN}	A^{NK}	A^{NJ}	A^{NU}	F^{NI}	F^{NM}	F^{NP}	F^{NS}	F^{NT}	F^{NC}	F^{NN}	F^{NK}	F^{NJ}	F^{NU}	LH^{N}	LE^{N}	LF^{N}	LG^{N}	LL^{N}	LW^{N}	Q^{N}	X^{N}
	Korea (K)	A^{KI}	A^{KM}	A^{KP}	A^{KS}	A^{KT}	A^{KC}	A^{KN}	A^{KK}	A^{KJ}	A^{KU}	F^{KI}	F^{KM}	F^{KP}	F^{KS}	F^{KT}	F^{KC}	F^{KN}	F^{KK}	F^{KJ}	F^{KU}	LH^{K}	LE^{K}	LF^{K}	LG^{K}	LL^{K}	LW^{K}	Q^{K}	X^{K}
	Japan (J)	A^{JI}	A^{JM}	A^{JP}	A^{JS}	A^{JT}	A^{JC}	A^{JN}	A^{JK}	A^{JJ}	A^{JU}	F^{JI}	F^{JM}	F^{JP}	F^{JS}	F^{JT}	F^{JC}	F^{JN}	F^{JK}	F^{JJ}	F^{JU}	LH^{J}	LE^{J}	LF^{J}	LG^{J}	LL^{J}	LW^{J}	Q^{J}	X^{J}
	USA (U)	A^{UI}	A^{UM}	A^{UP}	A^{US}	A^{UT}	A^{UC}	A^{UN}	A^{UK}	A^{UJ}	A^{UU}	F^{UI}	F^{UM}	F^{UP}	F^{US}	F^{UT}	F^{UC}	F^{UN}	F^{UK}	F^{UJ}	F^{UU}	LH^{U}	LE^{U}	LF^{U}	LG^{U}	LL^{U}	LW^{U}	Q^{U}	X^{U}
B		BA^{I}	BA^{M}	BA^{P}	BA^{S}	BA^{T}	BA^{C}	BA^{N}	BA^{K}	BA^{J}	BA^{U}	BF^{I}	BF^{M}	BF^{P}	BF^{S}	BF^{T}	BF^{C}	BF^{N}	BF^{K}	BF^{J}	BF^{U}								
H		HA^{I}	HA^{M}	HA^{P}	HA^{S}	HA^{T}	HA^{C}	HA^{N}	HA^{K}	HA^{J}	HA^{U}	HF^{I}	HF^{M}	HF^{P}	HF^{S}	HF^{T}	HF^{C}	HF^{N}	HF^{K}	HF^{J}	HF^{U}								
W		WA^{I}	WA^{M}	WA^{P}	WA^{S}	WA^{T}	WA^{C}	WA^{N}	WA^{K}	WA^{J}	WA^{U}	WF^{I}	WF^{M}	WF^{P}	WF^{S}	WF^{T}	WF^{C}	WF^{N}	WF^{K}	WF^{J}	WF^{U}								
D		DA^{I}	DA^{M}	DA^{P}	DA^{S}	DA^{T}	DA^{C}	DA^{N}	DA^{K}	DA^{J}	DA^{U}	DF^{I}	DF^{M}	DF^{P}	DF^{S}	DF^{T}	DF^{C}	DF^{N}	DF^{K}	DF^{J}	DF^{U}								
Value Added (V)	V1	$V1^{I}$	$V1^{M}$	$V1^{P}$	$V1^{S}$	$V1^{T}$	$V1^{C}$	$V1^{N}$	$V1^{K}$	$V1^{J}$	$V1^{U}$																		
	V2	$V2^{I}$	$V2^{M}$	$V2^{P}$	$V2^{S}$	$V2^{T}$	$V2^{C}$	$V2^{N}$	$V2^{K}$	$V2^{J}$	$V2^{U}$																		
	V3	$V3^{I}$	$V3^{M}$	$V3^{P}$	$V3^{S}$	$V3^{T}$	$V3^{C}$	$V3^{N}$	$V3^{K}$	$V3^{J}$	$V3^{U}$																		
	V4	$V4^{I}$	$V4^{M}$	$V4^{P}$	$V4^{S}$	$V4^{T}$	$V4^{C}$	$V4^{N}$	$V4^{K}$	$V4^{J}$	$V4^{U}$																		
X		X^{I}	X^{M}	X^{P}	X^{S}	X^{T}	X^{C}	X^{N}	X^{K}	X^{J}	X^{U}																		

Source: IDE (1998).

Note: LH, LE, LF, LG, LL and LW = exports to Hong Kong, United Kingdom, France, West Germany, East Germany and the Rest of the World (ROW), respectively, Q = statistical discrepancy, X = total output, B = freight and insurance, H and W = imports from Hong Kong and the ROW, respectively, D = import duty and sales tax, V1 = wages and salary, V2 = operating surplus, V3 = depreciation of fixed capital and V4 = indirect taxes less subsidies.