JESNA

THE JOURNAL OF ECONOMETRIC STUDY OF NORTHEAST ASIA (JESNA)

Vol. 6 No. 2 March 2009

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Economic Research Institute for Northeast Asia

THE JOURNAL OF ECONOMETRIC STUDY OF NORTHEAST ASIA (JESNA)

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The journal is published in English in principle twice a year.

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The Journal of Econometric Study of Northeast Asia

Vol. 6　No. 2　　March　2009

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The Impact of Asian Financial Liberalization using the Asian International Input–Output Model

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Abstract

The aim of this paper is to measure the degree of international financial liberalization of nine Asian countries, and additionally evaluate its impact on sector output and economic growth. The study focuses on the nine Asian countries which have been through or are in the process of financial liberalization. The nine Asian countries are Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, the Republic of Korea (ROK) and Japan. The analysis integrates a financial model with the Asian international input–output model in such a way that the change in the degree of financial liberalization can have an impact on real sectors in the international input–output model and the impact on the real sectors can connect back to the financial model as well.

KEYWORDS: *Financial liberalization, international input–output model, Asian countries*

JEL Classification: C51 (Model construction and estimation), C53 (Forecasting and other model application)

1. Introduction

Since the Asian financial crisis there has been widespread doubt about the merit of international financial liberalization. International financial liberalization refers to the degree to which an economy does not restrict cross-border financial transactions. This liberalization was implemented from the late 1980s and was blamed as being one of the causes of the crisis. Edwards (2001) assessed the effect of financial liberalization on economic growth using cross-country data. That study estimated the average real GDP growth using a measure of the financial openness, along with other variables, which affect economic performance, as explanatory variables. The study found that countries with a higher degree of financial openness had higher economic growth than the ones with restricted capital mobility. In contrast, Vlachos and Waldenström (2005) evaluated the impact of international financial liberalization at the industrial level across countries. That study estimated industrial output growth as a function of; 1) the degree of external dependence (a measurement created by Rajan and Zingales, 1989) multiplied by the degree of financial liberalization; 2) the degree of external dependence multiplied by the level of financial development; and 3) other factors related to industrial growth. The study found no higher growth in industries that were highly dependent on external financing in countries with a higher degree of financial liberalization. Analysis using aggregate data or industry-level data could yield different results. The impact of international financial liberalization is still ambiguous and remains an issue with policy implications.

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This study focuses on output using industry-level data as well as national-level data from the Asian international input–output tables developed by the Institute of Developing Economies and the Japan External Trade Organization (IDE-JETRO). The financial model consists of a measure of the degree of international financial liberalization and related financial variables, including interest rates, net capital flows, exchange rates, and predicted exchange rates. The financial model was later linked with the Asian international input–output model and the impact on industrial and aggregate output was determined.

2. The Measure of the Degree of International Financial Liberalization

Before considering the impact of international financial liberalization, the measure of the degree of international financial liberalization should be clearly defined. There are, however, a number of approaches to measuring the degree of international financial liberalization.

Firstly, a *saving–investment correlation approach* was introduced by Feldstein and Horioka (1980). With perfect financial liberalization there should be a weak correlation between domestic saving and domestic investment, as funds would be able to move freely between countries in order to take advantage of investment opportunities. The study assessed the relation between the saving rate and the investment rate using Equation 1:

$$\left(\frac{I}{Y}\right)_i = a + b\left(\frac{S}{Y}\right)_i \tag{1}$$

where $\left(\frac{I}{Y}\right)_i$ is the ratio of domestic investment to GDP in country i and $\left(\frac{S}{Y}\right)_i$ is the ratio of domestic saving to GDP in country i.

Secondly, the *Interest Parity Condition (IPC)* refers to the equalization between the expected returns on domestic and foreign assets (see Equation 2):

$$(1 + r_t) = E_t\left((1 + r_t^*) * (e_{t+1}/e_t)\right) \tag{2}$$

where r_t and r_t^* are the domestic and foreign interest rate rates, respectively. e_t is the exchange rate in terms of domestic currency per US dollar. (e_{t+1} refers to the next time-period.) E_t is the expectation operator. Montiel (1994) measured the degree of financial liberalization based on a return differential (see Equation 3):

$$d_t = (1 + r_t) - \left((1 + r_t^*) * (e_{t+1}/e_t)\right) \tag{3}$$

Since the expected value of $\left((1 + r_t^*) * (e_{t+1}/e_t)\right)$ was not observable, the measure was based on the ex-post rate of return. In international financially liberalized markets the mean value of the return differential should be zero and the deviation from the mean should be serially uncorrelated. The degree of international financial liberalization was measured by the ratio of its mean absolute deviation from the IPC to the mean of the exchange-rate–corrected foreign interest rate. If the ratio has a relatively low value, the degree of international financial liberalization is high. The study found mixed results ranging from high- to low-level international financial liberalization, depending on the country.

Thirdly, Edwards and Khan (1985) and Haque and Montiel (1990) measured the degree of financial openness as being the extent to which domestic interest rates were linked to foreign interest rates. The model assumed that the domestic market clearing interest rate (r) is a weighted average of the uncovered-interest-parity interest rate, the foreign exchange rate adjusted by the expected change in the exchange rate $\left(r^{*}+\dot{e}\right)$, and the autarky interest rate where the financial market is completely closed $\left(r^{/}\right)$:

$$r=\varphi\left(r^{*}+\dot{e}\right)+(1-\varphi)r^{/} \quad ;\text{ where } \ 0\leq\varphi\leq 1 \tag{4}$$

The parameter φ indicates the degree of international financial liberalization. If $\varphi=1$, the financial market is completely liberalized internationally, and the domestic-market–clearing interest rate is equal to its uncovered parity value. If $\varphi=0$, the financial market is completely closed domestically. Subsequently the autarky interest rate $\left(r^{/}\right)$ is determined under autarky money-market equilibrium.

Fourthly, Ghosh and Ostry (1995) utilized a *consumption smoothing approach* to assess the degree of international financial liberalization. If the degree of international financial liberalization was high, the economy should be able to completely smooth consumption in the face of shocks. This implies that the current account should be used as a buffer to smooth aggregate consumption in the face of shocks to national cash flow, defined as output less investment less government expenditure. If cash flow were expected to fall over time, it would be optimal to run up a current account surplus in order to be able to consume more in the future. On the other hand, if cash flow were expected to grow over time, it would be optimal to run up a current account deficit. They employed a Granger causality test to discover whether the current account data would be able to predict the subsequent movement in the national cash flow. They then estimated the optimal capital flow and compared the optimal capital flow with the actual data for the current account in order to test the statistical properties of the estimated parameters.

Fifthly, Quinn (1997, 2003) constructed *cross-country indicators* for the degree of financial liberalization. The Quinn index measures various aspects of financial regulation based on the *Annual Report on Exchange Arrangements and Exchange Restriction (AREAER)* published by the IMF. The Quinn index had a value from 0 (the lowest degree of international financial liberalization) to 14 (the highest degree of international financial liberalization).

Finally, Chinn and Ito (2006) created a cross-country index of capital openness (KAOPEN) based on AREAER. KAOPEN is based on binary dummy variables in four major categories; a variable indicating the presence of multiple exchange rates, a variable indicating a restriction on current account transactions, a variable indicating a restriction on capital account transactions, and a variable indicating the requirement of the surrender of export proceeds. The study resulted in KAOPEN, which is the first standardized principal component of these four dummy variables.

3. The International Financial Model

After reviewing the approaches to measuring the degree of international financial liberalization, in this study we employed the measurement based on *interest parity condition (IPC)* and the *determination of domestic interest rate* (Edwards and Khan, 1985; and Haque and Montiel, 1990). Our rationale was that interest rates and exchange rates play an important role in both the financial model and the Asian international input–output model. Therefore the measurement of the degree of financial liberalization should be closely related to the two variables to facilitate the simulation and inter-linkage of the two models.

The determination of the domestic market clearing interest rate (r) is a weighted average of two interest rates representing a completely liberalized financial market $(r^* + \dot{e})$ and a completely closed financial market (r'):

$$r = \varphi(r^* + \dot{e}) + (1 - \varphi)r' \quad ; \quad 0 \le \varphi \le 1 \tag{4}$$

As the autarky interest rate (r') is unobservable, r' would be recovered using an expression of the money supply (MS) identity:

$$MS = DC + R = DC + R_{-1} + \Delta R \tag{5}$$

where MS is the domestic money supply, DC is the stock of domestic credit outstanding, R is the international reserves held by the central bank, R_{-1} is the international reserves in the previous time-period, ΔR is the change in international reserves. Thus the balance of payment identity:

$$CA + NKI = \Delta R \tag{6}$$

where CA is the current account and NKI is the net capital inflow. Substituting Equation 6 into Equation 5 we get:

$$MS = DC + R_{-1} + CA + NKI \tag{7}$$

The money supply corresponding to a completely closed financial market (MS') refers to the situation when there is no movement of funds into or out of the country $(NKI = 0)$. Therefore this can be expressed as:

$$MS' = DC + R_{-1} + CA = MS - NKI \tag{8}$$

Assuming that the money demand (MD) has the conventional functional form we get:

$$\log(MD / P) = \alpha_0 - \alpha_1 r + \alpha_2 \log(rGDP) + \alpha_3 \log(MS_{-1} / P_{-1}) \tag{9}$$

where MD/P is the real money demand, $rGDP$ is the real gross domestic product, and $\alpha_1, \alpha_2, \alpha_3 > 0$. Next the interest rate corresponding to a closed financial market (r') is derived from the money market equilibrium by equating money supply with money demand, $\log\left(\frac{MS_t^/}{P_t}\right) = \log\left(\frac{MD_t}{P_t}\right)$:

$$\log\left(\frac{MS'}{P}\right) = \alpha_0 - \alpha_1 r' + \alpha_2 \log(rGDP) + \alpha_3 \log\left(\frac{MS_{-1}}{P_{-1}}\right) \tag{10}$$

$$r' = (\alpha_0/\alpha_1) - (1/\alpha_1)\log\left(\frac{MS'}{P}\right) + (\alpha_2/\alpha_1)\log(rGDP) + (\alpha_3/\alpha_1)\log\left(\frac{MS_{-1}}{P_{-1}}\right) \tag{11}$$

Lastly, r' is substituted back into Equation 4, resulting in a final functional form for the determination of the domestic interest rate:

$$r = \varphi(r_{U.S.} + \dot{e}) + (1-\varphi)\left(\frac{\alpha_0}{\alpha_1}\right) - (1-\varphi)\left(\frac{1}{\alpha_1}\right)\log\left(\frac{MS'}{P}\right) + (1-\varphi)\left(\frac{\alpha_2}{\alpha_1}\right)\log(rGDP) + (1-\varphi)\left(\frac{\alpha_3}{\alpha_1}\right)\log\left(\frac{MS_{-1}}{P_{-1}}\right) \tag{12}$$

The econometrically estimated Equation 12 yields an estimate of the degree of international financial liberalization, parameter φ.

Regarding the remainder of the international financial model, this study is mainly based on the Marwah–Klein model of exchange rate determination and capital flow. The expected future exchange rate, $E(e_{t+1})$, the current value of the exchange rate, e_t, and the net capital inflow, NKI_t, are estimated. Using them to calculate the expected change in the exchange rate, $\dot{e} = (E(e_{t+1}) - e_t)/e_t$, the expected exchange rate of the next time-period is assumed to follow an adaptive expectation, where the current value of the exchange rate and the past value of the exchange rate determine the expected future exchange rate:

$$E(e_{t+1}) = \zeta_0 + \zeta_1 e_t + \zeta_2 e_{t-1} + \zeta_3 e_{t-2} \tag{13}$$

The current value of the exchange rate is assumed to follow the Filatov–Klein exchange rate model, written as:

$$\ln e_t = \beta_0 + \beta_1 \ln(P_t/P_{U.S.,t}) + \beta_2(r_t - r_{U.S.,t}) + \beta_3(CA_t/GDP_t) \tag{14}$$

where P_t is the domestic general price level, and $P_{U.S.,t}$ is the general price level of the United States.

The net capital inflow (NKI_t) is determined by the current account and the difference between the domestic and world interest rates under an interest parity condition (IPC). Under perfect financial liberalization, the interest parity condition must be satisfied, meaning an equalization of the expected returns on the domestic and rest of the world rates:

$$(1+r_t) = E_t\left((1+(r_{US})_t)*(e_{t+1}/e_t)\right) \tag{15}$$

Regarding net capital inflow in a liberalized financial market, when the domestic interest rate is higher than the IPC interest rate, $(1+r_t) > E_t\left((1+(r_{US})_t)*(e_{t+1}/e_t)\right)$, there would be a massive capital inflow reaching to infinity. In reality, the net capital inflow is positively related to the two-interest-rate differential, (d_t), but does not have an infinite value:

$$d_t = (1+r_t) - E_t\left((1+(r_{US})_t)*(e_{t+1}/e_t)\right) \tag{16}$$

Next the net capital flow can be represented as the following function:

$$NKI_t = \vartheta_0 - \vartheta_1 CA_t + \vartheta_2 d_t \qquad : \vartheta_1, \vartheta_2 > 0 \tag{17}$$

In total the international financial model consists of four equations for each economy, namely: the domestic interest rate (Equation 12); the expected exchange rate (Equation 13); the exchange rate (Equation 14); and the net capital flow (Equation 17). The measurement of the degree of international financial liberalization can be recovered after the estimation of the domestic interest rate, Equation 12. We then simulated a scenario where φ increases by 20%, as a case study for the increasing degree of international financial liberalization. The impact on interest rates and exchange rates would be passed onto the Asian international input–output (AIIO) model.

4. The Asian International Input–Output (AIIO) Model

The important variables that play a critical role in the Asian international input–output model are sector output and sector price. To incorporate the exchange and interest rates into the model, this study links the exchange rate to the determination of sector price. On the other hand, the interest rate affects sector output via the determination of final demands, namely investment. This section attempts to explain the entire modeling process starting from data preparation to model construction. In particular, the following steps are carried out in this study:

Step 1: Converting the variables in the AIIO table from US dollars to national currencies

Step 2: Calculating sector prices given the data of value added prices

Step 3: Converting all the variables in current prices into those in constant prices

Step 4: Estimating the final demand equations and incorporating the interest rate into the investment equation
Step 5: Estimating the intermediate demand and output
Step 6: Zero profit condition and price determination
Step 7: Linking with the international financial model

Step 1: Converting the variables in the AIIO table from US dollars to national currencies

The Asian international input–output (AIIO) model is based on four datasets of the AIIO table, for 1985, 1990, 1995, and 2000. The AIIO table recorded all the variables representing the economic activities of the nine Asian countries and the United States in US-dollar terms. Among the nine Asian economies, however, most do not have a fixed exchange rate with the US dollar. Moreover, most production and consumption are in domestic currencies rather than US dollars. Hence, the AIIO model should be in the local currency of each country and all the variables in the AIIO table have to be converted into national currency using exchange rate data from *International Financial Statistics* published by the International Monetary Fund.

Step 2: Calculating sector prices given the data of value added prices

In order to convert the variables in the AIIO table from current price into constant price, we used the United Nation's data on nominal and real GDP by industry in national currencies. We then computed the GDP deflators by industry with 2000 as the base year. The UN's GDP deflators correspond to the deflators for value added in the AIIO model. According to the AIIO model, sector price is calculated in a zero-profit condition where total revenue equals total cost (see Equation 18):

$$xv_j^k = \sum_i \sum_h xv_{ij(h)}^k + va_j^k \tag{18}$$

where xv_j^k is the total revenue of the j^{th} industry in the k^{th} economy, $xv_{ij(h)}^k$ is the intermediate input cost of the i^{th} commodity from the h^{th} economy used in the production of the j^{th} sector in the k^{th} economy, and va_j^k is the value added of the j^{th} sector in the k^{th} economy.

Total revenue is the sector price multiplied by the sector output, $xv_j^k = p_j^k x_j^k$, where p_j^k is the sector price of the j^{th} industry in the k^{th} economy and x_j^k is the sector output of the j^{th} sector in the k^{th} economy. The intermediate input cost is the import price multiplied by the intermediate input demand, $xv_{ij(h)}^k = q_{ij(h)}^k x_{ij(h)}^k$, where $q_{ij(h)}^k$ is the import price of the i^{th} commodity from the h^{th} economy to the j^{th} sector production in the k^{th} economy and $x_{ij(h)}^k$ is the intermediate input of the i^{th} commodity from the h^{th} economy used in the production of the j^{th} sector in the k^{th} economy.

The UN's GDP deflators are equivalent to the value added prices, pva_j^k, in the AIIO framework, which can be expressed as:

$$pva_j^k = \frac{xv_j^k - \sum_i \sum_h xv_{ij(h)}^k}{\frac{xv_j^k}{p_j^k} - \sum_i \sum_h \frac{xv_{ij(h)}^k}{q_{ij(h)}^k}} \quad (19)$$

The exchange rate is incorporated into Equation 19 via the import price of intermediate input, $q_{ij(h)}^k$. The import price of the i^{th} commodity import from the h^{th} country of origin is defined as the sector price of the i^{th} sector from the h^{th} economy, converting from the h^{th} currency unit into the k^{th} currency unit, $q_{ij(h)}^k = \frac{p_i^h e^k}{e^h}$, where e^k is the exchange rate of the k^{th} currency unit per US dollar and e^h is the exchange rate of the h^{th} currency unit per US dollar. The exchange rate is then incorporated into the intermediate input price, and Equation 19 can be rewritten as:

$$pva_j^k = \frac{xv_j^k - \sum_i \sum_h xv_{ij(h)}^k}{\frac{xv_j^k}{p_j^k} - \sum_i \sum_h \frac{xv_{ij(h)}^k}{\left(p_i^h * e^k / e^h\right)}} \quad (20)$$

Rearranging Equation 20 results in:

$$p_j^k = \frac{xv_j^k}{\sum_h \sum_i \frac{xv_{ij(h)}^k}{\left(p_i^h * e^k / e^h\right)} + \frac{xv_j^k - \sum_i \sum_h xv_{ij(h)}^k}{pva_j^k}} \quad (21)$$

Using Equation 21 for all sectors and all countries would yield the sector price in the AIIO model.

Step 3: Converting all the variables in current prices into those in constant prices

After calculating the sector prices, all the variables are ready to be converted from the current price in national currency to the constant price in national currency. By dividing nominal variables by sector price, the outcome would be real variables. Conversion from current price to constant price is necessary for the determination of the sector output, represented as:

$$X = AX + F \quad (22)$$

where X is the vector of gross output, A is the technical coefficient matrix, and F is the matrix of final demand.

Step 4: Estimating the final demand equations and incorporating the interest rate into the investment equation

Final demand is classified into four categories, $M = C, G, I, V$: private consumption (C) , government consumption (G) , investment (I) , and inventory (V) . The matrix of final demand can be expressed as $F = \left[f_{iM(h)}^{k}\right]$, where $f_{iM(h)}^{k}$ is the final demand *M* of the k^{th} economy for the i^{th} commodity imported from the h^{th} economy. This study determines private consumption and investment endogenously. Government consumption and inventory, however, are assumed as fixed, according to the AIIO 2000 table.

a) Private Consumption Demand

Private consumption of the k^{th} economy is defined as $cpr^{k} \equiv \sum_{i}\sum_{h} f_{iC(h)}^{k}$. Private consumption demand is a function of real national wage income, $\left(\frac{wage^{k}}{pc^{k}}\right)$. Real national wage income in the k^{th} economy is calculated as the sum of sector wages, $\left(\sum_{j} wage_{j}^{k}\right)$, divided by the average consumer price $\left(pc^{k}\right)$. We had to econometrically estimate the private demand function in Equation 23 using pool data from the AIIO tables:

$$\log\left(cpr^{k}\right) = \lambda 0^{k} + \lambda 1^{k} \log\left(\frac{wage^{k}}{pc^{k}}\right) \tag{23}$$

After estimating the aggregate private consumption $\left(cpr^{k}\right)$, private consumption by commodity $\left(cpr_{i}^{k}\right)$ also had to be determined. We defined private consumption of the i^{th} commodity of the k^{th} economy and its consumption share as $cpr_{i}^{k} \equiv \sum_{h} f_{iC(h)}^{k}$, and $scp_{i}^{k} \equiv \frac{cpr_{i}^{k}}{cpr^{k}}$, respectively. The consumption shares of the i^{th} commodity are assumed to share a constant elasticity of substitution (CES), expressed as:

$$scp_{i}^{k} = \gamma_{c}^{k}\left[pc_{i}^{k} / pc^{k}\right]^{\mu_{c}^{k}} \tag{24}$$

where pc_{i}^{k} is the consumer price of the i^{th} commodity in the k^{th} economy, pc^{k} is the weighted average of pc_{i}^{k}, and γ_{c}^{k} and μ_{c}^{k} are behavioral parameters, with μ_{c}^{k} representing the elasticity of substitution among the consumption commodities in the k^{th} economy. We econometrically estimated private consumption by commodity using Equation 25:

$$\log\left(scp_{i}^{k}\right) = \vartheta 0_{i}^{k} + \vartheta 1_{i}^{k} \log\left(pc_{i}^{k} / pc^{k}\right) \tag{25}$$

where the estimated value of $\vartheta 1_i^k$ represents the elasticity of substitution.

After estimating private consumption by commodity, we applied Armington's (1969) trade elasticity approach to determine the share of private consumption by import origin:

$$s_{iC(h)}^k = \gamma_{ic}^k \left[p_{iC(h)}^k / pc_i^k \right]^{\mu_{ic}^k} \tag{26}$$

Here $s_{iC(h)}^k$ is the trade share of the i^{th} commodity imported from the h^{th} economy for private consumption in the k^{th} economy: $s_{iC(h)}^k \equiv f_{iC(h)}^k \big/ \sum_h f_{iC(h)}^k$. $p_{iC(h)}^k$ is the import price of the i^{th} commodity from the h^{th} economy for private consumption in the k^{th} economy: $p_{iC(h)}^k = \left(p_i^h * e^k / e^h \right)$. pc_i^k is the weighted average of $p_{iC(h)}^k$. γ_{ic}^k and μ_{ic}^k are behavioral parameters. μ_{ic}^k is the elasticity of substitution of the i^{th} consumption commodity among the various import origins. We estimated the following:

$$\log\left(s_{iC(h)}^k\right) = \delta 0_{iC}^k + \delta 1_{iC}^k \log\left(p_{iC(h)}^k / p_{iC}^k\right) \tag{27}$$

Summaries of the equations for private consumption at the aggregate level $\left(cpr^k\right)$, at the commodity level $\left(cpr_i^k\right)$, and at the import origin level $\left(f_{iC(h)}^k\right)$ are illustrated in Figure1.

Figure 1 Private Consumption Equations

Aggregate private consumption:	$\log\left(cpr^k\right) = \lambda 0^k + \lambda 1^k \log\left(\frac{wage^k}{pc^k}\right)$
Private consumption by commodity:	$cpr_i^k = scp_i^k * cpr^k$;
	where $\log\left(scp_i^k\right) = \vartheta 0_i^k + \vartheta 1_i^k \log\left(pc_i^k / pc^k\right)$
Private consumption by import origin:	$f_{iC(h)}^k = s_{iC(h)}^k * cpr_i^k$:
	where $\log\left(s_{iC(h)}^k\right) = \delta 0_{iC}^k + \delta 1_{iC}^k \log\left(p_{iC(h)}^k / p_{iC}^k\right)$

b) Investment demand

The investment demand of the k^{th} economy $\left(ir^k \equiv \sum_i \sum_h f_{iI(h)}^k \right)$ is determined by the total output of the k^{th} economy and the real interest rate. The total output of the k^{th} economy is the summation of sector output, $\sum_j x_j^k$. The real interest rate for the investment in the k^{th} economy is the nominal interest rate minus the rate of change in the average price of investment goods, $\left(r^k - \ln pi^k \right)$. We estimated Equation 28:

$$\log\left(ir^k\right) = \iota 0^k + \iota 1^k \log\left(\sum_j x_j^k \right) + \iota 2^k \left(r - \ln pi^k \right) \tag{28}$$

After the aggregate investment has been determined, the investment by commodity $\left(ir_i^k \equiv \sum_h f_{iI(h)}^k \right)$ had to be identified. The commodity composition of investment is assumed to be of a fixed proportion, and not to vary with the change in the relative price of the i^{th} commodity. Investment demand by commodity is determined from $ir_i^k = sir_i^k * ir_i^k$, where sir_i^k is investment share by commodity in year 2000:

$$\overline{sir_i^k} = \left(\sum_h f_{iI(h)}^k \Big/ \sum_i \sum_h f_{iI(h)}^k \right)_{t=2000} \tag{29}$$

As with private consumption demand, we applied Armington's trade elasticity approach to determine the commodity investment demand classified by import origin, as shown in Equation 30:

$$\log\left(s_{iI(h)}^k\right) = \delta 0_{iI}^k + \delta 1_{iI}^k \log\left(p_{iI(h)}^k \big/ p_{iI}^k \right) \tag{30}$$

where $s_{iI(h)}^k \equiv f_{iI(h)}^k \Big/ \sum_h f_{iI(h)}^k$. $p_{iI(h)}^k$ is the import price of the i^{th} commodity from the h^{th} economy for investment in the k^{th} economy, $p_{iI(h)}^k = \left(p_i^h * e^k / e^h \right)$. p_{iI}^k is the average price of the i^{th} investment commodity in the k^{th} economy, measured as a weighted average of $p_{iI(h)}^k$. Summaries of the investment equations are illustrated in Figure 2.

Figure 2 Investment Equations

Aggregate investment:	$\log\left(ir^k\right) = \iota 0^k + \iota 1^k \log\left(\sum_j x_j^k\right) + \iota 2^k \left(r^k - \ln pi^k\right)$
Investment by commodity:	$ir_i^k = sir_i^k * ir_i^k$; where $\overline{sir_i^k} = \left(\sum_h f_{iI(h)}^k \Big/ \sum_i \sum_h f_{iI(h)}^k\right)_{t=2000}$
Investment by import origin:	$f_{iI(h)}^k = s_{iI(h)}^k * ir_i^k$:
	where $\log\left(s_{iI(h)}^k\right) = \delta 0_{iI}^k + \delta 1_{iI}^k \log\left(p_{iI(h)}^k / p_{iI}^k\right)$

Step 5: Estimating the intermediate demand and output

From the determination of gross output, $X = AX + F$, intermediate demand is expressed as *AX*. Each element within *A* can be written as:

$$a_{ij(h)}^k = x_{ij(h)}^k \Big/ x_j^k \tag{31}$$

where $a_{ij(h)}^k$ is the technical coefficient identifying how much the i^{th} commodity from the h^{th} economy is used in one unit of production of the j^{th} sector in the k^{th} economy. $x_{ij(h)}^k$ is the intermediate input of the i^{th} commodity from the h^{th} economy used in the production of the j^{th} sector in the k^{th} economy. x_j^k is the gross output of the j^{th} sector in the k^{th} economy. a_{ij}^k is defined as:

$$a_{ij}^k = \sum_h x_{ij(h)}^k \Big/ x_j^k \tag{32}$$

where $\sum_h x_{ij(h)}^k$ is the summation of the intermediate inputs of the i^{th} commodity from various sources. In the model, a_{ij}^k is assumed as constant in year 2000, while $a_{ij(h)}^k$ can vary depending on import prices and the domestic prices of inputs. As with final demand, we applied Armington's constant elasticity approach to determine the intermediate input share from various origins (see Equation 33):

$$\log\left(s_{ij(h)}^k\right) = \delta 0_{ij}^k + \delta 1_{ij}^k \log\left(q_{ij(h)}^k / p_{ij}^k\right) \tag{33}$$

where $s_{ij(h)}^k \equiv x_{ij(h)}^k \big/ x_{ij}^k$, and $q_{ij(h)}^k$ is the import price of the i^{th} commodity from the h^{th} economy to the j^{th} sector production in the k^{th} economy. p_{ij}^k is the weighted average of $q_{ij(h)}^k$. The intermediate demand equations are summarized in Figure 3.

Figure 3 Intermediate Demand Equations

Intermediate demand by commodity	$x_{ij}^{k} = a_{ij}^{k} * x_{j}^{k}$; where $\overline{a_{ij}^{k}} = \left(\sum_{h} x_{ij(h)}^{k} \Big/ x_{j}^{k} \right)_{t=2000}$
Intermediate demand by import origin:	$x_{ij}^{hk} = s_{ij(h)}^{k} * x_{ij}^{k}$;
	where $\log\left(s_{ij(h)}^{k}\right) = \delta 0_{ij}^{k} + \delta 1_{ij}^{k} \log\left(q_{ij(h)}^{k} \Big/ p_{ij}^{k}\right)$

After we had finished estimating the final demand and intermediate demand equations, the gross output determination had to be calculated using $X = AX + F$.

Step 6: Zero profit condition and price determination

Under the AIIO framework, sector price is determined by the zero profit condition where total revenue is equal to total cost (see Step 2). Unlike Step 2, however, where the value added price is obtained from the UN's GDP deflator, we wanted to endogenize valued added price, specifically wages, into the model. The zero profit condition could be expressed as:

$$p_{j}^{k} x_{j}^{k} = \sum_{i} \sum_{h} q_{ij(h)}^{k} x_{ij(h)}^{k} + w^{k} l_{j}^{k} + vo_{j}^{k} \qquad \text{where } va_{j}^{k} = w^{k} l_{j}^{k} + vo_{j}^{k} \tag{34}$$

w^{k} stands for the wage rate of the k^{th} economy. l_{j}^{k} stands for the employment in the j^{th} sector of the k^{th} economy. The sector wages of the j^{th} sector of the k^{th} economy could be expressed as: $wage_{j}^{k} = w^{k} l_{j}^{k}$. vo_{j}^{k} stands for the other value added of the j^{th} sector of the k^{th} economy, an exogenous variable.

The wage rate of the k^{th} economy $\left(w^{k}\right)$ is the function of labor productivity, $\left(\frac{\sum_{j} x_{j}^{k}}{\sum_{j} l_{j}^{k}} \right)$ (see Equation 35):

$$\log\left(w^{k}\right) = \xi_{0} + \xi_{1} \log\left(\frac{\sum_{j} x_{j}^{k}}{\sum_{j} l_{j}^{k}} \right) \tag{35}$$

The sector employment is determined by the Ozaki (1979) employment function, which can be expressed as:

$$l_{j}^{k} = a_{j}^{k} \left(x_{j}^{k}\right)^{\sigma_{j}^{k}} \tag{36}$$

where a_j^k is the employment coefficient in the j^{th} sector of the k^{th} economy and σ_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 the model through the elasticity of labor input.

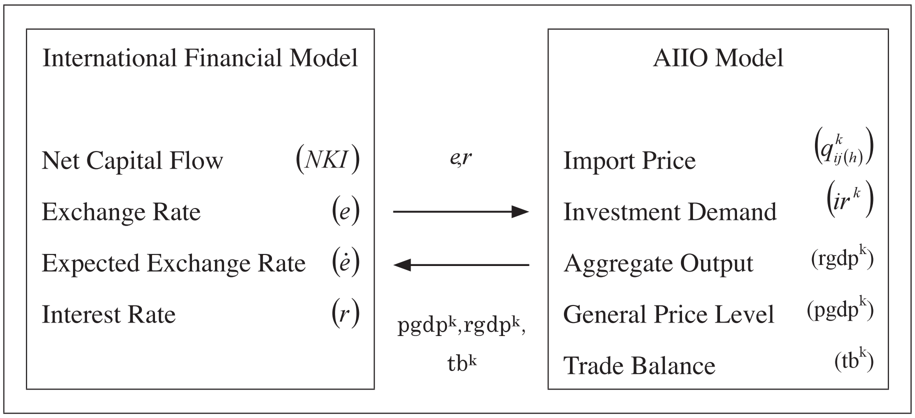
The price determination could be derived by dividing Equation 34 by x_j^k, which can be written as:

$$p_j^k = \frac{\sum_i \sum_h q_{ij(h)}^k x_{ij(h)}^k}{x_j^k} + \frac{w^k l_j^k}{x_j^k} + \frac{vo_j^k}{x_j^k} \tag{37}$$

Step 7: Linking with the international financial model

After finishing the modeling of the AIIO model, we linked the financial model and the AIIO model. The interest rate and exchange rate are the variables in the financial model that have an impact on the AIIO model. The interest rate has an impact on investment demand, whereas the exchange rate has an impact on import prices and sector price determination. From the AIIO model, the sum of the sector output can be considered as the aggregate output, equivalent to real GDP. The aggregate output from the AIIO model would have an impact on the exchange rate as well as the domestic interest rate. Moreover, changes in the average price from the AIIO model can be considered equivalent to the general price level in the financial model. This has an impact on the fundamental exchange rate. Finally, the trade balance (exports minus imports) from the AIIO model can also be considered as a major part of the current account, which has an impact on net capital inflow (NKI). The feedback between the two models would continue until the variables converged.

Figure 4 The International Financial and AIIO Models



5. Estimation of the Degree of Financial Liberalization

All variables in the financial model are based on quarterly data (1980—2005) from *International Financial Statistics* published by the International Monetary Fund (IMF).

Data on interest rates are based on the lending rate, representing the long-term interest rate for investment decision. The long-term government bond rate would have been a very good candidate to represent the long-term interest rate, but data are missing for many Asian countries. Therefore we decided to use the lending rate as the long-term interest rate.

The international financial model is built as a system of simultaneous equations using the two-stage least-square (2SLS) estimation method. In the model, the sample data is subdivided into three periods: before financial liberalization (1980—1989); after financial liberalization and before the Asian financial crisis (1990—1997); and after financial liberalization and after the Asian financial crisis (1998—2005). We hypothesized that there may have been some change in the parameter of the degree of financial liberalization in the period 1980—2005. We employed the Chow test to evaluate any significant change in the parameter. In all countries, there is significant change between the periods 1980—1989 and 1990—2005; yet only Japan, Taiwan, and Thailand show significant change between the periods 1990—1997 and 1998—2005 (see Table 1).

Table 1 The Expected Values of the Degree of Financial Liberalization in the Period 1980–2005

	Before	After Financial Liberalization	
	Financial Liberalization	Before Asian Crisis	After Asian Crisis
	1980-1989	1990-1997	1998-2005
1 Singapore	0.336	0.598	0.598
	(3.921)***	(3.655)***	(3.655)***
2 Japan	0.468	0.477	0.515
	(4.07)***	(2.256)***	(3.423)***
3 Philippines	0.010	0.458	0.458
	(0.04)	(2.013)***	(2.013)***
4 Thailand	0.124	0.490	0.424
	(1.110)	(1.686)**	(1.354)*
5 Taiwan	0.454	0.401	0.414
	(3.532)***	(6.161)***	(3.454)***
6 Malaysia	0.293	0.392	0.392
	(0.561)	(2.020)***	(2.020)***
7 Indonesia	0.220	0.376	0.376
	(1.823)**	(1.383)*	(1.38)*
8 ROK	0.229	0.364	0.364
	(3.395)***	(1.676)**	(1.676)**
9 China	0.299	0.332	0.332
	(1.471)	(1.863)**	(1.863)**

Notes: The values in parentheses are *t*-values
* denotes statistically significant at a 20%-level of significance
** denotes statistically significant at a 10%-level of significance
*** denotes statistically significant at a 5%-level of significance

Table 2 Ranking by the Chinn-Ito Index of Financial Openness in the Period 1980–2005

	Before Financial Liberalization	After Financial Liberalization	
		Before Asian Crisis	After Asian Crisis
	1980-1989	1990-1997	1998-2005
1 Singapore	1	2	2
2 Japan	2	1	1
3 Philippines	8	5	4
4 Thailand	5	6	6
5 Taiwan	-	-	-
6 Malaysia	3	4	5
7 Indonesia	4	3	3
8 ROK	6	7	7
9 China	7	8	8

Source: compiled from Chinn and Ito, (2006), *A New Measure of Financial Openness*.

In Table 1, most of the estimated values of the degree of financial liberalization are statistically significant at the 10% level. For the Philippines, Malaysia, and China, the estimated values of the degree of financial liberalization become statistically significant in the period after financial liberalization. For Indonesia and Thailand after the Asian financial crisis, although the estimated values are not significant at the 10% level they are almost so, and are at least significant at the 20% level. For most of the countries, the degree of financial liberalization increased between the periods of 1980—1989 and 1990-onward. For Taiwan, although the degree of financial liberalization has not increased, it has not drastically changed throughout 1980—2005. After financial liberalization, the degree of financial liberalization is extremely high in Singapore and Japan ($\varphi \geq 0.5$) . The Philippines, Thailand, and Indonesia are countries that experienced a drastic change in their degrees of financial liberalization ($\Delta\varphi \geq 1.5$) between the periods of 1980—1989 and 1990-onward. After financial liberalization, the degree of financial liberalization is relatively high in the Philippines, Thailand and Taiwan ($0.4 \leq \varphi \leq 0.5$). The degree of financial liberalization is moderate in Malaysia, Indonesia, the ROK, and China ($0.3 \leq \varphi \leq 0.4$) .

To allow comparison with other studies, this study uses the Chinn-Ito index of financial openness, as this index is available for 181 countries and territories from 1970 to 2006. Regarding Asian countries, the two highest ranked in Chinn-Ito index terms match the two countries that have the highest degree of financial liberalization. Moreover, after financial liberalization, the two lowest ranked in Chinn-Ito index terms match the two countries that have the lowest degree of financial liberalization. In general the degree of financial liberalization in this study matches the Chinn-Ito index relatively well—theirs being the latest study on the degree of financial openness that covers the broadest range of countries.

After estimating the degree of financial liberalization via the domestic interest rate equation, we recovered the estimated value of all the parameters $(\varphi, \alpha_0, \alpha_1, \alpha_2, \alpha_3)$ as shown in Table 3 and Table 4. We then focused on the scenario where φ was raised 20%, while keeping the other parameters constant.

Table 3 Estimation of the Domestic Interest Rates (Equation 12) used in the Scenario Analysis

Singapore $r = 13.719 + 0.598(r_{U.S.} + \dot{e}) - 2.939\log(MS'/P) + 0.014\log(rgpd)$ (3.656)*** (-1.290)* (1.576)* Adjusted R-square = 0.507
Japan $r = 73.065 + 0.515(r_{U.S.} + \dot{e}) - 5.413\log(MS'/P) + 6.044\log(MS/P)_{-1}$ (3.423)*** (-1.301)* (1.560)* Adjusted R-square = 0.413
Philippines $r = 57.535 + 0.458(r_{U.S.} + \dot{e}) - 6.278\log(MS'/P) + 1.099\log(rgpd)$ (2.013)*** (-2.245)*** (0.182) Adjusted R-square = 0.460
Thailand $r = 50.402 + 0.424(r_{U.S.} + \dot{e}) - 6.066\log(MS'/P) + 0.579\log(rgpd) + 7.663(d9798)$ (1.354)* (-2.858)*** (1.937)** (3.536)***
Taiwan $r = 81.630 + 0.414(r_{U.S.} + \dot{e}) - 8.530\log(MS'/P) + 0.0002\log(rgpd)$ (3.454)*** (-3.119)*** (1.743)** Adjusted R-square = 0.575
Malaysia $r = 4.743 + 0.393(r_{U.S.} + \dot{e}) - 11.486\log(MS'/P) + 11.594\log(MS/P)_{-1} + 1.887(d9798)$ (2.020)*** (-3.452)*** (2.884)*** (1.374)*
Indonesia $r = 209.204 + 0.376(r_{U.S.} + \dot{e}) - 14.534\log(MS'/P) + 1.493\log(rgpd) + 12.064(d9798)$ (1.383)* (-3.883)*** (0.311) (7.028)*** Adjusted R-square = 0.550
ROK $r = 81.658 + 0.364(r_{U.S.} + \dot{e}) - 7.732\log(MS'/P) + 3.916\log(MS/P)_{-1} + 9.006(d9798)$ (1.676)** (-2.204)*** (1.063) (5.556)*** Adjusted R-square = 0.651

China

$$r = 149.085 + 0.332(r_{U.S.} + \dot{e}) - 19.775\log(MS'/P) + 7.412\log(rgdp) + 11.604\log(MS/P)_{-1}$$

(1.863)** (-2.622)*** (2.595)*** (1.374)*

Adjusted R-square = 0.773

Notes: The values in parentheses are *t*-values
* denotes statistically significant at a 20%-level of significance
** denotes statistically significant at a 10%-level of significance
*** denotes statistically significant at a 5%-level of significance

Table 4 The Expected Values of the Parameters in the Domestic Interest Rate Equation

	φ	α_0	α_1	α_2	α_3
Singapore	0.598	4.668	0.137	0.005	0.000
Japan	0.515	13.499	0.090	1.117	0.000
Philippines	0.458	9.164	0.086	0.175	0.000
Thailand	0.424	8.309	0.095	0.095	0.000
Taiwan	0.414	9.569	0.069	0.00003	0.000
Malaysia	0.393	0.413	0.053	0.000	1.009
Indonesia	0.376	14.394	0.043	0.103	0.000
ROK	0.364	10.561	0.082	0.000	0.506
China	0.332	7.539	0.033	0.375	0.587

6. Estimation of Investment Demand and Private Consumption Demand

After simulating the scenario of a 20% increase in the degree of financial liberalization, the main channel of impact toward sector and aggregate output was the interest rate channel. A change in the domestic interest rate would lead to a change in investment and subsequently aggregate output. Since the AIIO model is based on four AIIO-table datasets, the estimation of investment demand and private consumption demand needed to be based on panel data (see Tables 5 and 6). Although it would be best to estimate investment demand and private consumption demand for each country individually, we wanted to maintain consistency in the input–output framework. Therefore we relied on the original data from the AIIO tables rather than imports, investment and private consumption from other sources.

As can be seen in Table 5, investment demand is a function of the aggregate output and real interest rate. The estimation of the equation using pooled least-squares without a fixed effect is significant at the 5% level. Nevertheless, we believe that the investment equation should include cross-country differences. The scenario analysis is based on pooled least-squares with a fixed effect. The interest rate elasticity with respect to investment is -0.004, meaning that if the interest rate increased by 1%, investment demand would decrease by -0.004%.

Table 5 Estimation of the Investment Demand Equation of Asian Countries using Panel Data

Method: Pooled least-squared without fixed effect

$$\log\left(ir^k\right) = -2.705 + 1.029\log\left(\sum_j x_j^k\right) - 0.011\left(r^k - \log\left(pi^k\right)\right)$$

(108.007)*** (-2.426)*** Adjusted R-square =0.996

Method: Pooled least-squared with fixed effect

$$\log\left(ir^k\right) = -0.102 + 0.916\log\left(\sum_j x_j^k\right) - 0.004\left(r^k - \log\left(pi^k\right)\right)$$

(12.629)*** (-1.472)* Adjusted R-square = 0.997

Fixed effect

SGP = -0.431	MYS = -0.194
JPN = 0.506	IDN = 0.462
PHL = -0.293	ROK = 0.518
THA = 0.085	CHN = -0.007
TWN = -0.321	

Notes: The values in parentheses are *t*-values
* denotes statistically significant at a 20%-level of significance
** denotes statistically significant at a 10%-level of significance
*** denotes statistically significant at a 5%-level of significance

Table 6 Estimation of the Private Consumption Demand of Asian Countries using Panel Data

Method: Pooled least-squared with fixed effect

$$\log\left(cpr^k\right) = 3.867 + 0.833\log\left(\frac{wage^k}{pc^k}\right)$$

(9.781)*** Adjusted R-square = 0.996

Fixed effect

SGP = -1.043	MYS = -1.230
JPN = 0.529	IDN = 1.241
PHL = 0.308	ROK = 0.649
THA = 0.217	CHN = -0.327
TWN = -0.264	

Notes: The values in parentheses are *t*-values
* denotes statistically significant at a 20%-level of significance
** denotes statistically significant at a 10%-level of significance
*** denotes statistically significant at a 5%-level of significance

The change in investment has a direct impact on sector and aggregate output. The change in aggregate output has a further impact on national wage income. Hence the change in investment has an indirect impact on national wage income as well as on private consumption. Private consumption demand is illustrated in Table 6. The income elasticity with respect to private consumption is 0.833, meaning that if wage income increased by 1%, private consumption would increase by 0.833%.

7. Scenario Analysis of Increasing the Degree of Financial Liberalization

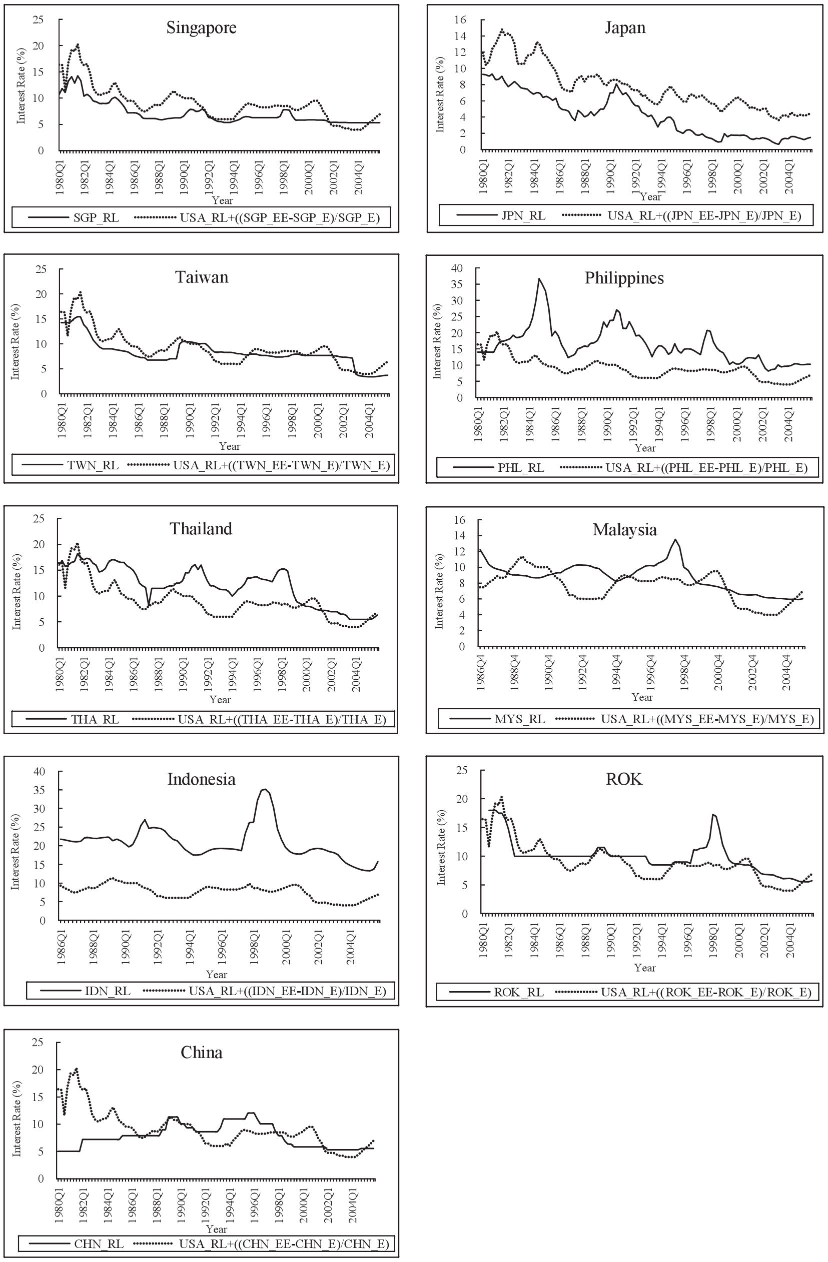
After estimating the financial and AIIO models, we focused on a scenario analysis where there is a 20% increase in the degree of financial liberalization while keeping the other parameters constant. An increase in the degree of financial liberalization results in a decline in interest rates in most Asian countries except Japan (see Table 7). Among the nine Asian countries, Japan is the only country that has a domestic interest rate lower than the interest parity rate of return throughout 1980—2005 (see Figure 5). Hence, an increase in the degree of financial liberalization would lower the gap between the domestic interest rate and the interest parity rate, leading to an increase in Japan's domestic interest rate.

As can be seen in Table 7, a 20% increase in the degree of financial liberalization has a very small impact on interest rates, ranging from -1.293% in Indonesia to 0.063% in Japan. Indonesia and the Philippines face a relatively significant decline in their interest rates of -1.293% and -0.957%, respectively, as these countries consistently maintain a positive and significant gap between the domestic interest rate and the interest parity rate of return.

Table 7 Impact of a 20% Increase in the Degree of Financial Liberalization on Macro-Variables

	% Change in Interest Rate	% Change in Investment	% Change in Aggregate Output
1 Singapore	-0.189	0.103	0.033
2 Japan	0.063	-0.036	-0.014
3 Philippines	-0.957	0.471	0.086
4 Thailand	-0.412	0.223	0.078
5 Taiwan	-0.073	0.040	0.014
6 Malaysia	-0.620	0.315	0.059
7 Indonesia	-1.293	0.713	0.232
8 ROK	-0.155	0.091	0.051
9 China	-0.081	0.052	0.025

Figure 5 Domestic Interest Rate and Interest Parity Rate of Return in the Asian Economy



Notes:

*k*_RL is the domestic interest rate of the k^{th} country

USA_RL+((*k*_EE-*k*_E)/*k*_E) is the interest parity rate of the k^{th} country, defined as the interest rate of the United States adjusting gain or loss in the exchange market of the k^{th} country where *k* includes:

Singapore (SGP), Japan (JPN), Taiwan (TWN), the Philippines (PHL), Thailand (THA), Malaysia (MYS), Indonesia (IDN), the Republic of Korea (ROK), and China (CHN)

The change in the interest rate has an impact on investment, for which we employed an interest rate elasticity of -0.004 with a country-specific effect. Therefore Indonesia and the Philippines, which have significantly lower interest rates, also have significantly higher investment demand. Finally, an increase in investment leads to an increase in aggregate output. The investment has a multiplier effect on aggregate output. Since sector prices are endogenous variables in the model, the values of the investment multipliers change as prices change. The effect of investment on aggregate output is shown in Table 7. Indonesia and the Philippines still have relatively higher increases in aggregate output of 0.232% and 0.086%, respectively. Note that any change in investment has a multiplier impact on aggregate output; the percentage change in aggregate output is lower than the percentage change in investment. This is because while investment increases by 1%, aggregate output increases by less than 1% (investment is only a fraction of aggregate output).

Regarding the change in sector production, construction is the sector that receives most of the benefit from the rising degree of financial liberalization, as construction is a major component of investment, highly sensitive to a decline in the interest rate. Construction ranks first in the increase in production in most of the Asian countries (see Table 8).

Table 8 Impact of a 20% Increase in the Degree of Financial Liberalization on Sector Output

	Agriculture	Mining and Utilities	Manufacturing	Construction	Trade and Transport	Services
Singapore	0.014	0.032	0.036	0.092	0.026	0.025
Japan	-0.014	-0.013	-0.014	-0.033	-0.014	-0.009
Philippines	0.140	0.071	0.068	0.421	0.072	0.036
Thailand	0.087	0.106	0.072	0.220	0.088	0.038
Taiwan	0.013	0.020	0.015	0.031	0.015	0.008
Malaysia	0.047	0.041	0.040	0.290	0.060	0.032
Indonesia	0.205	0.106	0.200	0.680	0.239	0.117
ROK	0.051	0.059	0.056	0.087	0.004	0.032
China	0.022	0.024	0.025	0.052	0.026	0.014

8. Conclusion and Limitations of the Study

In this study we placed an emphasis on modeling the financial system in Asian economies, as well as modeling the real sector using an international input–output model. The empirical study was based on an econometrically estimated equation system. Regarding the financial model, we found that Singapore and Japan had the highest degree of financial liberalization among the nine Asian economies. In Singapore and Japan, the domestic interest rate is synchronized with the world interest rate, adjusting for gains and losses in the exchange rate. On the other hand, the interest rate in China tends to move independently of the world interest rate.

The impact on aggregate production and sector production is evaluated by linking together the financial model and the international input–output model. An increase in the degree of financial liberalization tends to have a small positive impact for most Asian economies, except Japan. For Japan, the domestic interest rate is consistently lower than the interest parity rate of return. Therefore an increase in the degree of financial liberalization leads to a slight increase in the interest rate and a slight decline in aggregate output. In sector output construction is the sector that receives most benefit from higher financial liberalization, as this sector is the main component of investment demand.

Regarding the limitations of this study, the model does not take into account the capital structure of each production sector—whether the sector is highly dependent on domestic or foreign funding. This limitation is due to the lack of data on capital structure at the sectoral level for many Asian countries. Moreover, the investment demand function should also depend on cash flow as internal funds have played an important role on investment decisions in East Asian countries (see Nagano, 2005). It would be fruitful for further research to collect these data and apply them within a modeling framework.

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Identifying the Structural Changes of China's Spatial Production Linkages Using a Qualitative Input-Output Analysis

Shiro Hioki*, Geoffrey J.D. Hewings** & Nobuhiro Okamoto***

Abstract

In this paper, we attempt to identify the structural changes in China's interregional input-output linkages over the period 1987–1997 using the Minimal Flow Analysis (MFA) introduced by Schnabl (1994, 2001). MFA clearly reveals that some major changes in the structure of China's interregional linkages took place along with the increasing self-sufficiency of many regions. Although many interregional linkages between manufacturing industries within coastal areas have decreased in their relative importance, some new linkages with other industries and with other regions have gradually become more important over the same time period, leading us to conclude that in China the structure of the economic interdependencies between its spatial units is now being reorganized.

Keywords: *China; interregional linkages; input-output; market fragmentation; spatial interaction*

JEL classification: P2; O53; R12; R15.

1. Introduction

China has been experiencing a transition from a highly centralized planned economy to a market economy since economic reform began in 1978. During the three decades of reform, China has never had a negative growth rate—something that was common among other transitional countries in Eastern Europe and the Former Soviet Union (EEFSU). What is more, it has accomplished a rapid economic growth which is rare in world economic history. A great deal of research has been conducted to try to understand the process of this economic system transition. In those studies, the exceptional success of China, in comparison with the EEFSU countries, has largely been attributed to the characteristics of its reform strategies known as "gradualism," "incrementalism," "experimentalism," and "decentralism" etc. (see Lin et al., 1994, among others). A further issue, that has received far less attention, concerns the spatial aspects of the transitional economy: What influences have there been on the spatial configurations and the spatial interactions of the Chinese economy generated by its distinctive reform strategies?

With respect to the above questions, the fiefdom economy problem (*zhuhou jingji*) and market fragmentation has received the attention of many researchers on the Chinese economy. They argued that the Chinese economy looked like an aggregation of "fiefdom economies"; that is, regional economies each of which have strong decision-making powers over economic management inside the region and acts as if it were a dukedom relatively independent from the control of the central government. Against the background of the decentralization and dual-track reform, each region, driven by its own gain, tended to

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make duplicate investments in a small number of industries expected to be profitable. This tendency resulted in the convergence of industrial structure among regions and prepared the market fragmentation or “trade war” caused by local protectionism (Watson et al., 1989; Chen, 1994; World Bank, 1994; Wang, 2001).

In contrast to the strategies adopted by the regional governments, the central government has tried to establish the internal division of labor between regions based on their comparative strongpoints and to deepen the economic interdependency among them, accompanied by a strengthening of interregional economic linkages. For instance, with the beginning of the Ninth Five Year Plan, China launched the construction of seven major economic areas. By enhancing various kinds of interregional economic cooperation within each of these areas, this policy tried to accelerate the economic integration of the regions. In addition, the policy also aimed to build rational economic relationships between the areas based on their comparative strongpoints (Fan & Lu, 2001). Subsequently, since the beginning of the Western Development Program, large investments have been made to develop the infrastructure of the interior areas, which were expected to greatly enhance China’s interregional economic linkages (Huang & Wei, 2001). These examples prove that attaining a spatially more integrated market economy and establishing a spatial division of labor based on an economic rationale have been important policy objectives of China’s regional policy.

Given this recent economic background, several questions arise. How have China’s spatial economic linkages changed during the economic reform? Has China succeeded in deepening the economic interdependencies between its spatial units? How has China’s internal division of labor between its spatial units evolved? Quantitative analyses are needed to approach these problems, and the interregional input-output analysis is one of the basic methods for such a purpose. The object of this study is to identify the structural changes of China’s spatial input-output linkages using a qualitative input-output analysis, the Minimal Flow Analysis. At first, some important linkages are extracted from among all the intraregional and interregional input-output linkages of productive activities, and the structures those linkages constitute are identified by a simple graph-theoretic method. Then we apply the analysis to two time points after economic reform began, namely 1987 and 1997. The inter-temporal comparison of the results is expected to provide new insights into the changes in China’s spatial linkages.

Our analysis is different from the previous related research for several reasons. Previous studies on China’s spatial linkages are divided roughly into three types. (1) Research using econometric analyses to identify the existence of spillover effects (Chen, 1998; Ying, 2000; Brun et al., 2002). Although they revealed the volume and the pattern of China’s interregional spillover effects using different methods, the interest of their research is exclusively focused on the spillovers from the “growth poles” in coastal areas to the hinterland areas. Therefore the identifying of the structural changes of spatial linkages is left unanswered in their work. (2) Research using input-output techniques to identify China’s spatial structure (for example, Ichimura & Wang, 2003; Okamoto & Ihara, 2003) applied several basic input-output analyses and found some interesting results related to China’s interregional linkages. They failed, however, to consider the structural changes since their work lacked an inter-temporal analysis. (3) Research analyzing the relationship between the integration of the Chinese domestic market and local protectionism using quantitative methods (Xiong, 1993;

World Bank, 1994; Young, 1999; Park et al., 2002; Kato & Chen, 2002; Naughton, 2003; Bai et al., 2004; Poncet, 2003 and 2004). These analyses tried to identify the evolution of China's domestic market integration (or disintegration) and its causes, using various kinds of methods and data—however debate exists on whether China's domestic market has disintegrated more with the deepening of economic reform (Young and Poncet) or has gradually integrated (Kato and Chen, Naughton and Bai et al.). Park et al. conclude that there is no strong evidence to support the former point of view, seemingly favoring the latter. Our analysis is expected to provide an additional perspective to the recent debate by directly showing the structural changes in China's interregional intermediate transactions.

The remainder of this paper is organized as follows: Section 2 briefly explains the basic data: that is, China's interregional input-output tables and the methodology we use in this research. Section 3 presents and discusses the main empirical results. Section 4 presents the concluding remarks.

2. Data and Methods

2-1. Data

We use two sets of China's interregional input-output tables as the most basic statistical data for our research. One is a 1997 table (IDE/JETRO, 2003) and the other is a 1987 table (Ichimura et al., 2003).

There is reasonable comparability between both tables even though there are several discrepancies in sectoral and regional classifications between them. The activities included in each sector are presented in Table 1, showing that there are some differences in the activities contained in the corresponding sectors for the two years. The most notable discrepancy between them is that communication services are included in Sector 7 in the 1987 column, but in Sector 9 in the 1997 column. In 1997, the ratio of transportation output to transportation plus communication output is 72% and the ratio of service plus communication output to service alone is 108%. These figures suggest that we should take the degree of error into account to a certain extent, especially when we consider the results for the transportation sector (Sector 7). The provinces included in each region are shown in Table 2. There are two discrepancies.[1] One is that Inner Mongolia is included in North China in the 1987 table but in the Northwest in the 1997 table. As for North China, the ratio of gross regional output based on the 1997 criteria compared to that based on the 1987 criteria is about 94%. As for the Northwest, this same ratio is 128%. These figures indicate that we should consider the error caused by this discrepancy, especially when we try to make a time series comparison on the Northwest. The other discrepancy is that Chongqing was an integral part of Sichuan Province in 1987, but in 1997 was separated off to become a municipal city. This does not give rise to any error in our analysis because both Sichuan and Chongqing are aggregated into the same regional unit, the Southwest. In order to avoid the errors derived from the discrepancies associated with sectoral coverage, we don't focus on the findings associated with the transportation sector. In addition, we will discover later that the findings of our analysis mainly relate to the interregional transactions between coastal

[1] Taiwan is not included in either table because of data limitations.

regions (North China, the Central Coast, and the South Coast) and two interior regions (the Northeast and Central China). Therefore the results of our analysis are thought to be quite robust regarding the error caused by the discrepancies in regional coverage stated so far. As a result, the problems concerning the inter-temporal comparability of the data are not so critical.

Table 1 The Correspondences between Sectors in 1987 and 1997

1987		1997	
1	Agriculture	1	Agriculture
2	Mining	2	Coal mining and processing
		3	Crude petroleum and natural gas products
		4	Metal ore mining
		5	Non-ferrous mineral mining
3	Light Industry	6	Manufacture of food products and tobacco processing
		7	Textile goods
		8	Articles of apparel, leather, furs, down and related products
		9	Sawmills and furniture
		10	Papermaking and paper products, printing and record medium reproduction
4	Energy Industry	11	Petroleum processing and coking
		24	Electricity, steam and hot water production and supply
		25	Gas production and supply
		26	Water production and supply
5	Heavy Industry	12	Chemicals
		13	Nonmetallic mineral products
		14	Metal smelting and pressing
		15	Metal products
		16	Machinery and equipment
		17	Transport equipment
		18	Electric equipment and machinery
		19	Electronics and telecommunications equipment
		20	Instruments, meters, cultural and office machinery
		21	Maintenance and repair of machinery and equipment
		22	Other manufacturing products
		23	Scrap and waste *
6	Construction	27	Construction
7	Transport and communication **	28	Transport and warehousing
8	Wholesale and retail trade ***	29	Wholesale and retail trade
9	Services	30	Services

* "Scrap and waste" (Sector 23) is not included in the 1987 input-output table.
** "Communication" is included in "Services" for 1997.
*** "Wholesale and retail trade" in 1987 includes the catering industry. The latter is encompassed within "Services" for 1997.
Sources: Prepared by the authors from the Institute of Developing Economies-JETRO (2003) and Ichimura and Wang (2003).

Table 2 The Correspondences between Regions in 1987 and 1997

1987		1997	
Region	Provinces	Region	Provinces
Northeast	Liaoning, Jilin, Heilongjiang	Northeast	Liaoning, Jilin, Heilongjiang
North China	Beijing, Tianjin, Hebei, Shandong, Inner Mongolia	North Municipalities North Coast	Beijing, Tianjin Hebei, Shandong
East China	Shanghai, Jiangsu, Zhejiang	Central Coast	Shanghai, Jiangsu, Zhejiang
South China	Guangdong, Fujian, Hainan	South Coast	Guangdong, Fujian, Hainan
Central China	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi	Central China	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi
Northwest	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang	Northwest	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, Inner Mongolia
Southwest	Sichuan, Guizhou, Yunnan, Guangxi, Tibet	Southwest	Sichuan, Chongqing, Guizhou, Yunnan, Guangxi, Tibet

Sources: Prepared by the authors from the Institute of Developing Economies-JETRO (2003) and Ichimura and Wang (2003).

The basic economic indicators and the geographic extents of the regions are shown in Table 3 and Figure 1, respectively. From Table 3, we can understand some general characteristics of China's regional economies, such as that; (1) the coastal areas are more industrialized and developed than the interior areas; (2) the coastal areas, especially the South Coast and the Central Coast, are more open to the world economy than the interior areas, and (3) the coastal areas also have faster growth than the interior areas, etc. The South Coast and the Central Coast were projected to be growth centers for the whole Chinese economy by the central government and have enjoyed various preferential policies since the early phase of reform. It is also noteworthy that with good geography, the historical accumulation of productive resources which preceded liberalization, and various preferential policies, the Central Coast and the South Coast have gradually formed massive industrial agglomerations. These facts should be taken into consideration in the interpretation of the results of our analysis.

Figure 1 The Geographic Extents of the Regions

Note: This figure is based on the regional aggregation in 1997.

Table 3 Summary Statistics by Region [(1)]

1997	Northeast	North China	East China	South China	Central China	Northwest	Southwest
GDP (billion yuan)	773.8	1,474.9	1,467.9	1,072.6	1,638.8	354.4	900.2
Primary industry (%)	17	16	12	16	25	23	28
Secondary industry (%)	49	47	52	47	45	41	40
Tertiary industry (%)	34	36	36	37	31	36	32
Exports [(2)] (million dollars)	11,398	29,715	39,251	85,603	8,438	2,460	5,927
Incoming FDI [(3)] (million dollars)	3,352	8,185	12,104	16,619	7,832	720	1,728
Population (thousand persons)	104,282	197,772	128,756	109,754	349,808	88,068	238,880
Area (square km)	787,200	1,555,805	210,746	333,300	1,027,300	3,092,600	2,507,400
Population density (persons/ square km)	132	127	611	329	341	28	95
Per capita fixed assets (yuan)	2,002	2,734	4,494	3,127	1,365	1,512	1,135
Length of railway and highway (m/ sq km) [(4)]	180	144	351	494	311	48	134
Per capita GDP (yuan)	7,420	7,458	11,400	9,773	4,685	4,025	3,768
Growth rate of per capita GDP [(5)] (%)	7.5	10.3	11.5	13.1	9.1	7.5	8.5

(1) Regional classification is in accordance with that of the 1987 input-output table (see Table 2).
(2) Export value by location of China's foreign trade managing units.
(3) The FDI actually used.
(4) 1999 data.
(5) Average annual growth rate in real terms from 1987 to 1997.
Source: National Bureau of Statistics, *China Statistical Yearbook* (various years), China Statistics Press.

2-2. Methodology

We use the Minimal Flow Analysis (MFA) introduced by Schnabl (1994, 2001) to identify the structure of China's spatial input-output linkages.[2] MFA is a qualitative input-output analysis (QIOA), that aims to reveal the underlying structure of an input-output table by classifying which intermediate transactions are regarded as important (or unimportant). There is a rich body of literature on how to identify underlying fundamental economic structures in input-output tables. The methods range from ones using triangulation (Simpson & Tsukui, 1965, among others), to those associated with the concept of predictability (Jensen et al., 1988 and 1991), and qualitative input-output analysis (Aroche-Reyes, 1996 and 2002) etc. QIOA, in which MFA is included, is an approach that makes it possible to grasp the fundamental economic structure easily using digraphs derived from the application of graph theory on input-output tables. The reason why we apply MFA in this paper is that an inherent drawback of QIOA associated with transitivity is mitigated in MFA analysis. MFA (Schnabl, 2001) works with intermediary "layers" comprising a transaction matrix. Since the entries of the layer matrices decrease as the stage of the layers increases, MFA is able to avoid over-counting the number of important linkages, although conventional QIOA cannot because it usually works with a direct coefficient matrix which provides only one adjacency matrix.

In MFA, we begin with the decomposition of a transaction matrix into a number of layers by using the relationships given below:

$$T = A\langle X\rangle \tag{1}$$

In equation (1), A and $\langle X\rangle$ are the input coefficient matrix and a diagonal matrix of output vector X, respectively; T denotes the intermediate transaction matrix. Substituting X with the following equations,

$$X = RY \tag{2}$$

and

$$R = I + A + A^2 + A^3 + \cdots. \tag{3}$$

we obtain equation (4) representing the decomposition of T into several layers T^i ($i = 0,1,2,\cdots$);

$$T = T^0 + T^1 + T^2 + \cdots \tag{4}$$

where

$$T^0 = A\langle Y\rangle, T^1 = A\langle A\ Y\rangle, T^2 = A\langle A^2 Y\rangle, \cdots. \tag{5}$$

In equations (2) through (5), R, Y, and I denote the Leontief inverse matrix, the final demands vector, and the identity matrix, respectively. Note that the superscripts of T in equation (4) and (5) represent the layer number, not the exponential of each matrix.

The next step is to convert each matrix layer $T^i(i = 0,1,2,\cdots)$ to a corresponding adjacency matrix $W^i(i = 0,1,2,\cdots)$ using a given filter value, F. The filtering is implemented based on the following equation (6),

[2] The procedure explained here follows Schnabl (2001) with some slight changes in detail.

$$w_{ij}^k \begin{cases} = 1, & if \quad t_{ij}^k \geq F \\ = 0, & if \quad t_{ij}^k < F \end{cases} \quad (6)$$

where $W^k = \left(w_{ij}^k\right)$ and $T_{ij}^k = \left(t_{ij}^k\right)$, respectively.

The last step is to obtain a dependency matrix D and a connectivity matrix H from the adjacency matrices. The derivation of each matrix is based on the following equations:

$$D = \left(W(1) + W(2) + W(3) + \cdots\right) \quad (7)$$

and

$$H = D + {}^tD \quad (8)$$

where $W(i) = W^{i-1}W(i-1)$ for each of $i = 1, 2, 3 \cdots$ ($W(0) = I$). (9)

Note that the matrix multiplications in (9) and the summation of $W(\cdot)$ in (7) should be done in Boolean fashion. The summation in (8), however, follows usual algebraic rules. Each entry of the dependency matrix d_{ij} equals 1 if, and only if, there exist direct and indirect flows from sector i to sector j, which altogether total a value greater than or equal to a given filter value, F (Schnabl, 2001). Each entry of the connectivity matrix h_{ij} may take one of three possible values (0, 1, or 2). If h_{ij} takes the value 0, sector i and sector j are isolated. If h_{ij} takes the value 1, there is a unidirectional linkage between sector i and sector j. In this case, we can identify the direction of the flow by checking the value of d_{ij} and d_{ji} in D. If h_{ij} takes the value 2, there is a bilateral linkage between sector i and sector j, showing that there is a circular relationship in which two sectors are likely to generate both supply and demand impulses with one another.

MFA usually chooses the best filter value using the information maximization principle—however, we changed the methods at one point for a technical reason. The MFA procedure is performed 50 times for 50 equidistant filter levels, where F^1 is zero and F^{50} is the last filter value, which is identified by the value that makes the last bilateral link within H into a unilateral one when it is surpassed. Using 50 filter values, we can obtain 50 corresponding H matrices, from which we choose the one with the highest entropy (that is, the one with maximum information). The original procedure stated above can also be implemented in our research, but it makes the structure derived by the analysis overly complicated. The number of linkages contained in the structure becomes so large[3] that it is hard to grasp the structure easily. As a result, we apply the following method to determine a filter value more appropriate for our analysis. First, find the filter value to maximize the entropy and obtain the entropy value at the filtering level. Secondly, calculate the 20% value of the maximum entropy and choose a new filter value whose entropy value is nearest to the 20% value. In this research, we call the linkages found with this new filter value the "most important linkages." Thirdly choose another new filter value whose entropy value is nearest to 30% and specify a set of linkages with this filter value. Additional important linkages are

[3] This might be the case when the size of the input-output table is large like ours (63-sector by 63-sector) because the entropy-maximizing filter value is one at which there is a nearly equal number of differently qualified linkages in the connectivity matrix.

found by changing the filter values. These linkages are referred to as "linkages of secondary importance" in this research. By comparing the digraph of the most important linkages and linkages of secondary importance at different time points, we can identify the structural changes that took place in China's fundamental spatial linkages.

Finally, the sectors are divided into 3 groups with different characters (e.g. (1) source, (2) center and (3) sink) according to the centrality index of each sector. The centrality index here is defined as a ratio of the incoming to outgoing level for each sector. When we calculate the incoming and outgoing level of each sector, we total up 50 D matrices, each of which is identified with a filter value varying from F1 to F50, to obtain a cumulative matrix and observe the level of each sector within that matrix. Sectors with a centrality index that is more than 2.0 are identified as sinks, indicating that the sector has relatively more input linkages than output linkages. These sectors are thought to be located at the top of the hierarchy of intermediate transactions between sectors and/or supply more final goods than intermediate goods. Sectors with a centrality index of less than 1.0 are regarded as sources, indicating that the sectors have relatively more output linkages than input linkages. These sectors are thought to be relatively important sectors supplying intermediate goods to many sectors in the economy. Sectors with a centrality index between 1.0 and 2.0 are thought to have an intermediate character in this paper (and are called "centers").[4]

3. Empirical Results

3-1. Preliminary Analysis

Before turning to the MFA, it is appropriate for us to check the changes in the interregional input-output linkages briefly with some basic indicators. The indicators examined here show that the interregional input-output linkages as a whole have been more or less weakening during the period of our analysis. Table 4 presents the export and import ratio for each region.[5] Note that almost all the regions except the Northwest have increased in their level of autarky between 1987 and 1997. Table 5 shows output multipliers and input multipliers[6] measuring average backward and forward linkage effects, respectively. During the period in our analysis, overall backward and forward linkages in every region have increased considerably, showing that the degree of intermediation has been strengthened (this might be a common phenomenon observed in most growing economies). Industries in a given region, however, have mainly intensified their productive relationships with industries within that region (with the Northwest an exception), leading to the relative weakening of interregional linkages. It follows from these results that China's regional economies have moved to a state of increased self-sufficiency during the period in our analysis, which seems to confirm the reported tendencies that each region plans to develop independently.

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[4] In selecting the critical values of the interval, we used the following considerations as our basis: after removing outliers from the set of centrality indices for 1987, we found the maximum value to be 3.0. Dividing the value by three gives the lower threshold 1.0 and multiplying 1.0 by 2 gives the upper threshold, 2.0. The outliers relate to Sector 6, in which almost all the sales are classified into final demand in the Chinese input-output tables, (in other words, there are only negligible amounts of intermediate sales to other sectors), inevitably leading to extremely large centrality indices (becoming infinite in some cases). We therefore treated them as outliers.

[5] Exports and imports here only include export and import associated with intermediary goods because of the limitations of the data.

[6] Concerning output and input multipliers, see Miller and Blair (1985) and Hewings (1985).

Table 4 Export and Import Ratios by Region

	1987		1997	
	Export Ratio	Import Ratio	Export Ratio	Import Ratio
Northeast	20.1	18.5	8.7	12.5
North China	25.3	26.2	16.7	10.8
Central Coast	27.0	25.5	12.1	16.3
South Coast	19.6	24.7	13.5	17.7
Central China	23.0	21.9	20.8	13.7
Northwest	14.5	18.0	18.9	22.1
Southwest	15.5	15.2	11.1	14.2

Sources: Institute of Developing Economies-JETRO (2003) and Ichimura and Wang (2003).

3-2. Main Analysis

The results of our analysis show that some major changes took place in the structure of spatial linkages in China, although some unchanged factors were also found. Figures 2 and 3 show the structure of the most important linkages in 1987 and 1997, respectively. Note that if a sector is located further to the right-hand side of the ring for each region, then it means that that sector has a higher (or at least not lower) centrality index than sectors which are located further to the left-hand side of the ring. Therefore, sink sectors (depicted by circles with a normal line) and source sectors (depicted by circles with a broken line) are placed on the right- and left-hand sides of the rings, respectively, whereas central sectors (depicted by circles with a broad line) are placed in the central section of the ring. Some of the more important characteristics are highlighted in the remainder of this section.

(1) The character of each sector (e.g. its position in the hierarchy of a region in terms of the centrality index and whether it is a sink, central or source sector) is fairly stable during the decade except for a few changes. An observed tendency is that Sector 9 (i.e. Services) for almost all the regions moved more to the left-hand side of the rings (in other words, it tended to lower its relative position in the production hierarchy of each region), indicating that the sector has reinforced its intermediate sales to other sectors. Except for this change, however, the hierarchy is quite stable. The classification of sectors has not changed considerably, although there are a few changes, such as the decreasing source sectors in the Central Coast. The observed stability is plausible because the character of a sector is determined to a significant degree by its technical nature, which is likely to be stable during such a short time period.

(2) Most of the important intra- and interregional linkages shown in the figures tend to concentrate in three regions (e.g. North China, the Central Coast and Central China) and there are only a few important linkages in the other regions. This represents the uneven distribution of economic activity in China, with the concentration of linkages reflecting the significant concentration of economic activity in the same regions (see Table 3). It is noteworthy that with the present filter values, no important interregional linkage related to the western areas (i.e. the Northwest plus the Southwest) is identified for both years.

Besides, Table 5 shows that the backward linkage effects on the western areas by the coastal areas are very small, although they have slightly increased as a whole. These results imply that the volume of spillovers from the coastal areas to the western areas was limited through the 1990s. Bearing this point in mind, we can evaluate the ongoing Western Development Program as a timely scheme for the balanced growth of regions. Since the swift enhancement of spillovers from coastal areas cannot be predicted, formation of strong industrial bases within the western area may be essential to the acceleration of its growth. Furthermore, several major infrastructure projects in the strategy will strengthen spatial linkages with other regions and improve investment conditions, all of these gradually leading to the future increase of spillovers to the western area.

(3) The structure made by the bilateral linkages of 1997 is totally different from that of 1987. Bilateral linkages especially draw our attention because two sectors are expected to exercise positive influences on each other if they are linked bilaterally. In other words, bilateral linkages form "growth engines," because the growth of one sector stimulates intermediate transactions from the other, which in turn has repercussions on the first one. The bilateral structure of 1987 resembles a triangle whose apices are the heavy industries of North China, the Central Coast and Central China. In addition to these, the light industry and agriculture of the Central Coast have bilateral linkages with the heavy industries of North China and Central China. In this structure, the growth of the Central Coast might spill over easily to North China and Central China, and the growth of these two regions might in turn stimulate the growth of the Central Coast. Compared to 1987, the bilateral structure of 1997 is only made up of intraregional linkages and the service sectors seem to take a pivotal role in the structure. The changes in the bilateral structures between 1987 and 1997 might be attributed to two important changes taking place in the Chinese economy during the decade. One is that the deepened intermediation involved the relative increase of service inputs,[7] and the other is the increase in the self-sufficiency of each regional economy which we have already pointed out above.

For the purpose of identifying the changed and unchanged factors in the important linkages more effectively, we developed additional figures from Figures 2 and 3. Figure 4 shows the stable important linkages during the decade, while Figures 5 and 6 show the changes that took place in the important linkages. Note that the characteristics of sectors in terms of the centrality index in Figures 4, 5 and 6 are based on that of 1987. Hereafter, our attention will be focused on the interregional linkages.

[7] The development of China's service industries during the period is quite sluggish. For example, the share of tertiary industry in China's total GDP is almost unchanged during the period (29.3% in 1987 and 30.9% in 1997). Increases in the service industries, however, are observed in North China and the Central Coast, where the service sectors are positioned centrally in their bilateral-linkage structures. For example, the ratio of tertiary industry over regional GDP went up from 36.7% in 1987 to 54.5% in 1997 in Beijing, from 28.8% to 42.3% in Tianjin, and from 29.2% to 45.5% in Shanghai.

Table 5

5-1 Average Output Multipliers by Region in 1987 (Percentages of total)

	Total	Intra-regional	Inter-regional	Northeast	N. China	C. Coast	S. Coast	C. China	Northwest	Southwest
Northeast	100.0	83.8	16.2	—	7.7	3.8	0.6	3.3	0.3	0.5
North China	100.0	78.3	21.7	5.7	—	6.4	1.0	7.2	0.5	0.8
Central Coast	100.0	77.6	22.4	2.9	7.2	—	3.1	7.2	0.7	1.3
South Coast	100.0	76.9	23.1	2.2	4.4	8.1	—	4.6	0.6	3.2
Central China	100.0	80.6	19.4	2.0	4.4	9.6	1.2	—	0.7	1.5
Northwest	100.0	84.8	15.2	0.9	2.6	4.6	0.4	2.5	—	4.2
Southwest	100.0	86.1	13.9	0.8	1.4	5.0	2.1	2.6	2.0	—

Each number is an average of 9 sectors in a region.
Sources: Calculated by the authors from the Institute of Developing Economies-JETRO (2003) and Ichimura and Wang (2004).

5-2 Average Output Multipliers by Region in 1997 (Percentages of total)

	Total	Intra-regional	Inter-regional	Northeast	N. China	C. Coast	S. Coast	C. China	Northwest	Southwest
Northeast	100.0	85.2	14.8	—	5.3	3.3	1.3	3.5	0.9	0.6
North China	100.0	87.0	13.0	2.4	—	3.6	1.0	4.3	1.3	0.5
Central Coast	100.0	80.7	19.3	1.6	6.2	—	2.4	7.2	0.9	1.0
South Coast	100.0	80.2	19.8	0.9	4.1	5.0	—	6.3	0.8	2.5
Central China	100.0	84.5	15.5	0.9	5.5	4.4	1.7	—	1.7	1.2
Northwest	100.0	77.8	22.2	1.7	6.1	3.8	1.8	6.7	—	2.1
Southwest	100.0	83.6	16.4	0.7	3.3	3.0	2.7	5.1	1.5	—

Sources: as 5-1

5-3 Average Input Multipliers by Region in 1987 (Percentages of total)

	Total	Intra-regional	Inter-regional	Northeast	N. China	C. Coast	S. Coast	C. China	Northwest	Southwest
Northeast	100.0	80.9	19.1	—	8.3	5.0	1.6	3.3	0.3	0.6
North China	100.0	75.0	25.0	5.5	—	9.7	2.5	5.8	0.7	0.9
Central Coast	100.0	75.5	24.5	2.1	5.5	—	3.7	10.1	0.9	2.2
South Coast	100.0	80.0	20.0	1.1	2.5	9.4	—	3.8	0.3	2.9
Central China	100.0	75.1	24.9	2.7	8.1	9.3	2.7	—	0.6	1.5
Northwest	100.0	83.6	16.4	1.0	2.4	3.8	1.5	3.5	—	4.4
Southwest	100.0	83.9	16.1	0.7	1.9	3.7	3.5	3.9	2.3	—

Sources: as 5-1

5-4 Average Input Multipliers by Region in 1997 (Percentages of total)

	Total	Intra-regional	Inter-regional	Northeast	N. China	C. Coast	S. Coast	C. China	Northwest	Southwest
Northeast	100.0	86.5	13.5	—	4.9	3.7	1.3	1.9	1.0	0.7
North China	100.0	76.4	23.6	3.1	—	8.4	3.1	5.6	1.7	1.7
Central Coast	100.0	84.6	15.4	1.6	3.8	—	3.8	3.9	0.9	1.3
South Coast	100.0	84.5	15.5	1.2	1.7	6.3	—	3.2	0.8	2.3
Central China	100.0	73.3	26.7	2.1	4.8	10.2	4.8	—	2.0	2.7
Northwest	100.0	75.7	24.3	2.2	5.5	5.0	2.4	6.4	—	2.9
Southwest	100.0	84.7	15.3	0.8	1.4	3.7	4.7	3.1	1.6	—

Sources: as 5-1

Figure 2 Most Important Linkages in 1987

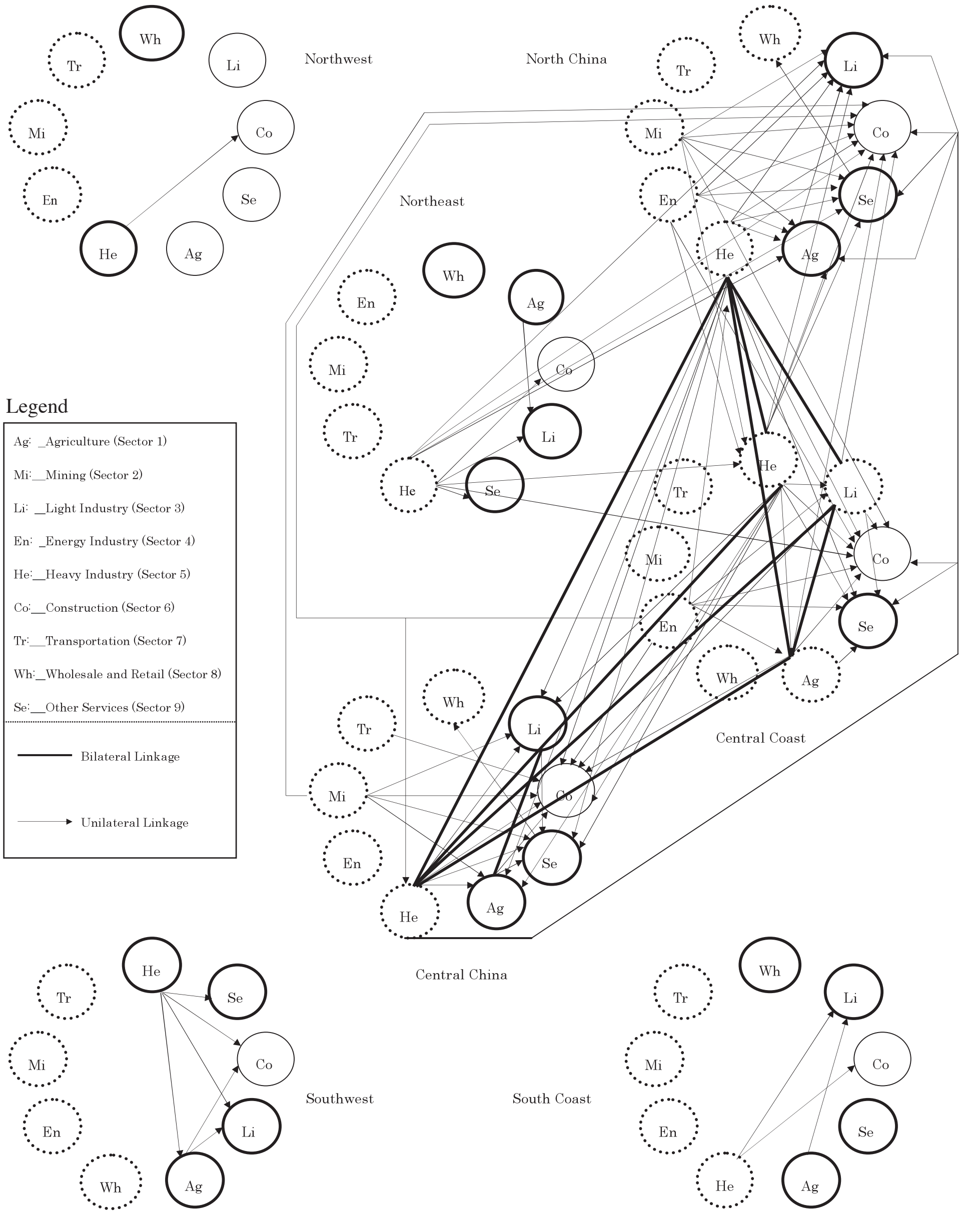


Figure 3 Most Important Linkages in 1997

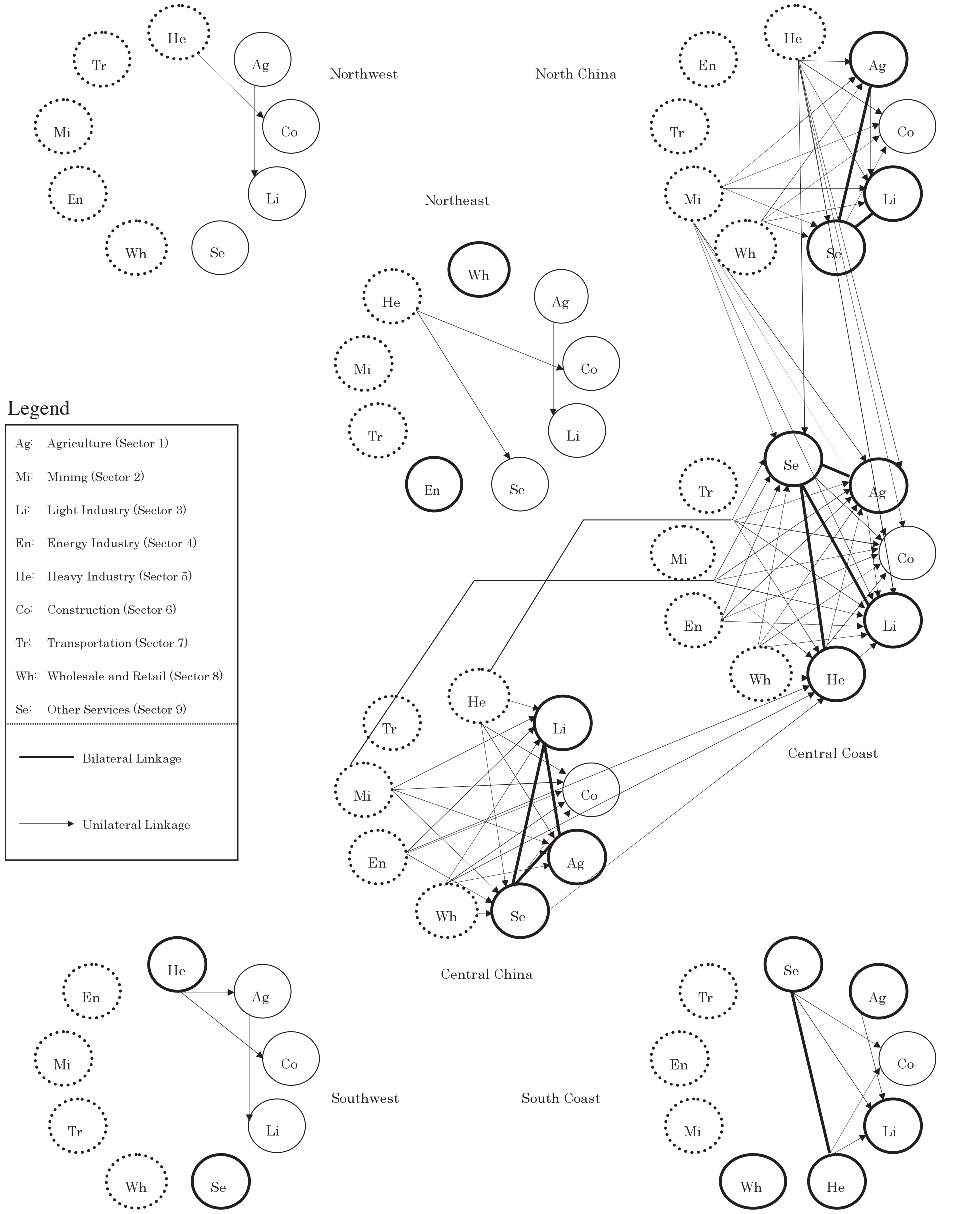
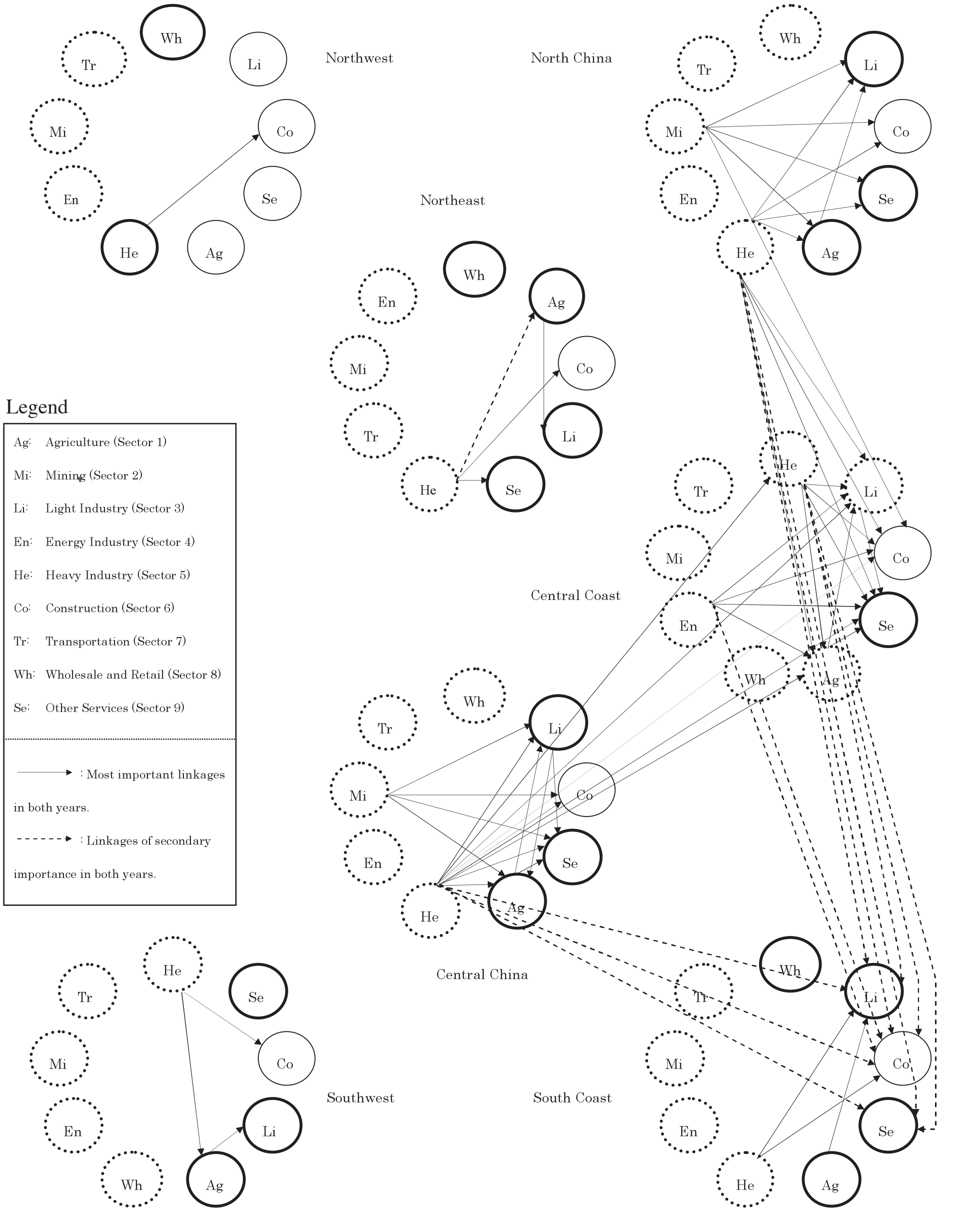


Figure 4 Stable Linkages



(4) In the Northeast and the Central Coast, which have long histories in manufacturing industries from the planning era or even earlier, it can be seen that many outgoing interregional linkages have changed to become relatively unimportant during the period in our analysis (see Figure 5). For instance, the linkages of the Northeast's heavy industry to various industries in North China and the Central Coast used to be very important in 1987, but had become relatively unimportant by 1997. In the case of the Central Coast, the same tendency is observed with respect to many sectors, such as heavy industry, light industry, and agriculture, etc. This major change is consistent with the large declines in the interregional forward linkage effects shown by the input multipliers in Table 5. In the case of the Northeast, this change might be attributed to the stagnation of the economy,[8] whereas the situation in the Central Coast will be considered briefly in the last part of this section.

The Northeast and the Central Coast show a common trend, as has already been stated. We should note an important difference between the Northeast and the Central Coast, however. In the case of the latter, although many outgoing linkages to North China and Central China have relatively weakened, some important outgoing linkages to the South Coast have emerged at the same time, as shown in Figures 5 and 6.[9] This fact is of interest because, from the perspective of spatial interactions, it clearly shows that the economic centroid of China has gradually moved from its northern to southern part.

[8] As shown in Table 6, the Northeast's economy has suffered from sluggish growth in comparison with other regions because state-owned enterprises (SOEs) in heavy industries, which had had a dominant position in its regional economy since the first five-year plan period (1953-1957), could not adapt easily to the growing market-economy environment. (The stagnation of the Northeast economy owing to the dominance of old SOEs in the economy is called "the Northeast Phenomenon" in China.)

[9] There are two reasons to explain the emerging linkages from the Central Coast to the South Coast. Although the average interregional input multiplier of the region shown in Table 5 exhibits a large decrease from 0.631 to 0.432, the portion of the South Coast adversely increases from 0.096 to 0.106. This partly explains the observed change. Another important reason is that the demand for the South Coast's manufacturing products (including exports from the region to overseas) relative to other regions increased rapidly, leading to the enforced linkages from several industries in the Central Coast to the South Coast. For example, the percentage of the demand for the South Coast's heavy industrial products within the national total goes up from 7.0% in 1987 to 14.5% in 1997 (almost the same change can be observed from the production side as shown in Table 6).

Figure 5 Weakening Linkages

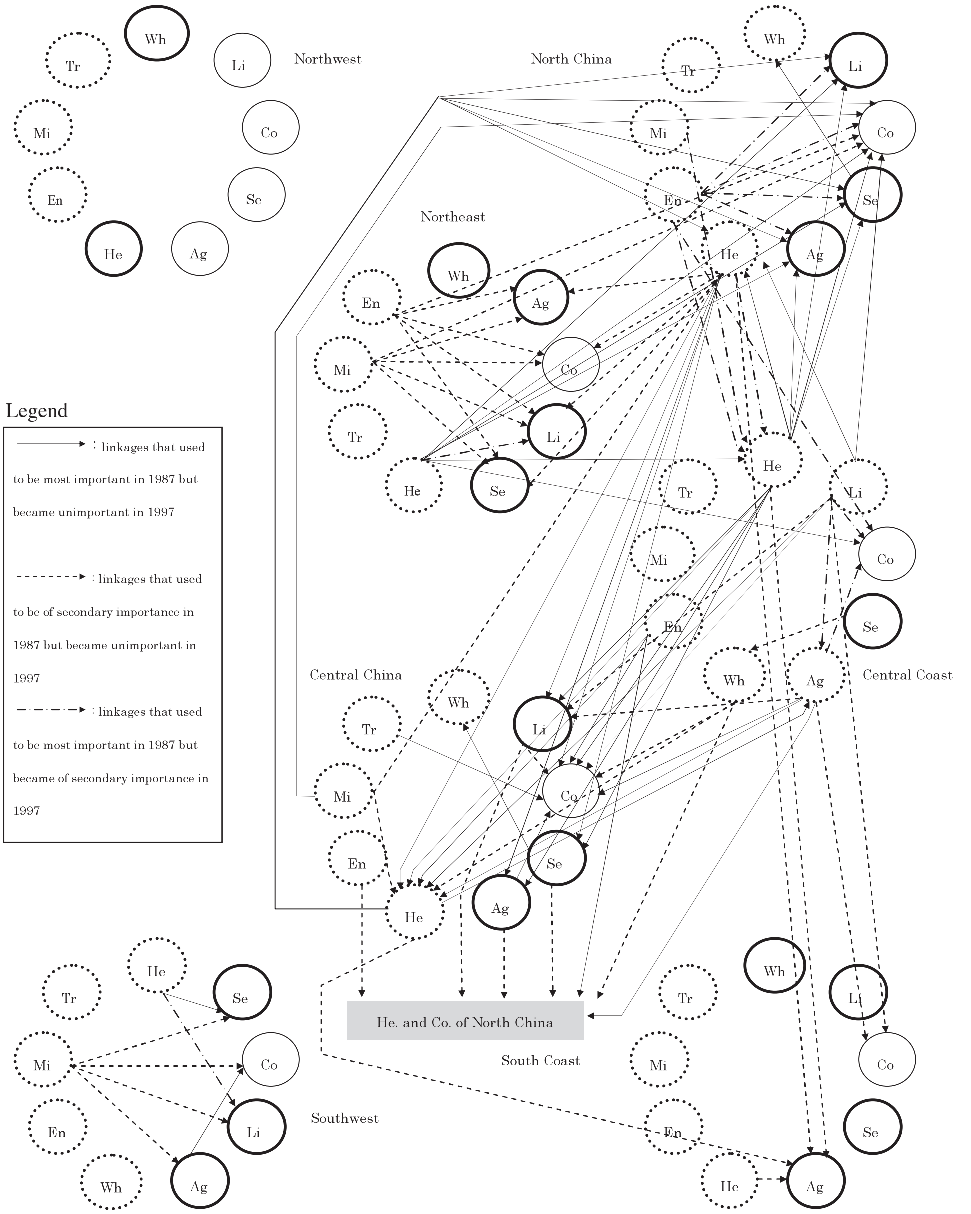


Figure 6 Strengthening Linkages

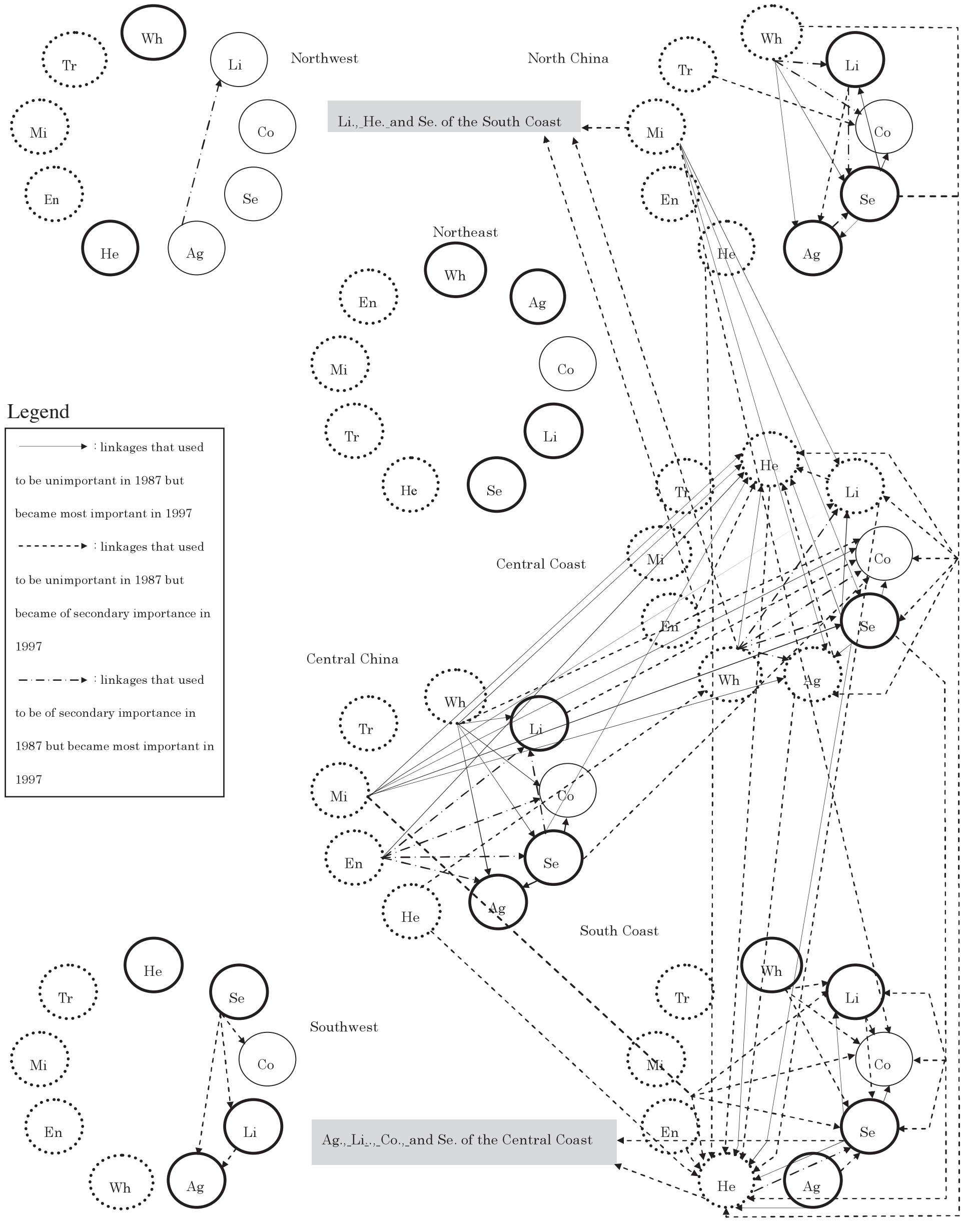


Table 6 Growth of Secondary Industries in each Region

(Unit: %)

	Average Annual Growth Rate		Share in National Total		
	1978–88	1988–98	1978	1988	1998
Liaoning	8.0	7.7	(2) 9.0	(4) 7.2	(7) 4.6
Jilin	10.4	8.7	2.4	2.4	1.7
Heilongjiang	5.9	8.2	(5) 5.9	(10) 3.9	2.6
Northeast	7.7	8.0	17.3	13.4	8.8
Beijing	7.6	8.6	(8) 4.3	3.3	2.3
Tianjin	8.6	9.0	3.2	2.7	1.9
Hebei	9.1	13.3	(6) 5.2	(7) 4.5	(6) 4.8
Shandong	(8) 11.8	(6) 15.0	(4) 6.6	(3) 7.4	(3) 9.1
Inner Mongolia	8.4	10.3	1.5	1.2	1.0
North China	9.6	12.6	20.7	19.1	19.1
Shanghai	7.7	10.2	(1) 11.7	(2) 9.0	(4) 7.3
Jiangsu	(4) 14.0	(10) 13.4	(3) 7.3	(1) 9.9	(2) 10.6
Zhejiang	(1) 18.2	(5) 15.2	3.0	(6) 5.8	(5) 7.3
Central Coast	11.9	12.8	22.0	24.7	25.2
Fujian	(3) 14.2	(1) 18.2	1.6	2.2	3.5
Guangdong	(2) 14.6	(2) 17.9	(7) 4.8	(5) 6.9	(1) 10.9
Hainan	9.7	(4) 15.2	0.2	0.2	0.2
South Coast	14.4	17.9	6.6	9.3	14.7
Shanxi	8.8	10.0	2.9	2.4	1.9
Anhui	(5) 13.0	(8) 14.6	2.2	2.8	3.3
Jiangxi	11.1	(7) 14.8	1.8	1.9	2.3
Henan	(7) 11.9	12.7	(9) 3.9	(8) 4.3	(8) 4.4
Hubei	(6) 12.8	12.6	3.5	(9) 4.3	(9) 4.4
Hunan	10.0	11.8	3.3	3.2	3.0
Central China	11.4	12.8	17.6	19.0	19.3
Shaanxi	10.1	9.9	2.3	2.2	1.8
Gansu	5.6	9.5	2.2	1.4	1.0
Qinghai	7.1	7.3	0.4	0.3	0.2
Ningxia	8.4	8.6	0.4	0.3	0.2
Xinjiang	9.0	10.9	1.0	0.9	0.8
Northwest	8.2	9.7	6.3	5.1	3.9
Guangxi	9.8	(9) 14.3	1.4	1.3	1.6
Chongqing	9.4	11.8	1.7	1.5	1.4
Sichuan	10.6	12.3	(10) 3.6	3.7	(10) 3.6
Guizhou	(9) 11.6	9.5	1.0	1.1	0.9
Yunnan	(10) 11.5	11.0	1.5	1.7	1.4
Tibet	-1.5	(3) 15.6	0.1	0.0	0.0
Southwest	10.5	12.0	9.4	9.4	8.9
National Avg. (Total)	10.5	12.6	100.0	100.0	100.0

Source: Hiroyuki Kato and Guanghui Chen. (2003), *East Asian Long-term Economic Statistics: China*, Keiso Shobo, pp. 312–314.

(5) In North China and Central China we can observe two common tendencies. First, in contrast to the case in the Northeast and the Central Coast stated above, the reduction of the outgoing interregional linkages is not so obvious. Although the linkages from the heavy industry of North China to various industries of the Northeast and Central China have relatively weakened, North China has started to build some new important linkages with other regions and/or in other sectors. The linkages from its mining industry and heavy industry to some industries in the Central Coast and the South Coast have intensified. Almost the same tendency is observed with respect to Central China. In addition, the interregional forward linkage effects shown by the input multipliers in Table 5 have increased considerably in absolute terms, indicating that these two regions have become more important as supply origins of intermediate goods.

Secondly, many of the incoming interregional linkages from the Central Coast and the Northeast to these two regions changed, becoming insignificant by 1997. For example, many linkages from agriculture, light industry, the energy industry and heavy industry of the Central Coast to the various industries of Central China have rapidly decreased in importance. In unit terms, the interregional backward linkage effects have also decreased considerably as the output multipliers of Table 5 show. The missing incoming linkages and the weakening backward effects indicate that North China and Central China have seen a decrease in their original dependence on the other regions (especially on the originally advanced industrial regions, such as the Northeast and the Central Coast) in the supply of intermediate goods, gradually increasing the self-sufficiency of their economies.

(6) The Central Coast and the South Coast are thought to be growth centers, which generate relatively large spillover effects to other regions (taking only the backward linkage effects into account). Although the structure involving the bilateral interregional linkages of the manufacturing industries of North China, the Central Coast and Central China has disappeared, we can still see from Figure 4 that almost all the stable important interregional linkages from the heavy industry of North China and Central China were absorbed by the industries of the Central Coast. In addition, the linkages from the mining industry of North China and Central China have become more important as shown in Figure 6. Moreover, although the interregional backward linkage effects of the Central Coast have decreased, those to Central China have increased in absolute terms. These facts indicate that the Central Coast has been an enduring source of input-output spillover to its surrounding regions, especially to Central China. On the other hand, the South Coast has become a receiver of various linkages of secondary importance from North China, the Central Coast and Central China. In other words, the South Coast can be regarded as an emerging growth center in the Chinese Economy.

It is beyond the scope of this paper to specify the reasons why China's regional economies have proceeded toward self-sufficiency with the deepening of economic reform. Nevertheless it is useful for further research to consider the possible reasons briefly. The bottlenecks in transportation have gradually been mitigated, because a large amount of investment has been made in the construction of infrastructure to enhance China's transportation capacity.[10] Moreover, some institutional factors have hindered China's market integration (such as the immaturity of interregional payment and settlement mechanisms),

[10] The ratio of investment in capital construction (*jiben jianshe*) of transportation and communication industries to nominal GDP increased from 16% in 1987 to 30% in 1997.

but these may have improved gradually along with the market-oriented reform. Taking these factors into consideration, the observed tendency toward self-sufficiency seems to be a somewhat unexpected result. The possible causes might be the following: (1) the inaccuracy of China's statistical information, (2) the formation of industrial clusters in coastal areas, (3) the influence of the fiefdom economy or the market fragmentation caused by local protectionism, and/or (4) the problems associated with the aggregation of regional units.

As Huenemann (2001) pointed out, it is possible that China's official transportation statistics have been unreliable because of the rapid liberalization and the privatization that took place during the reform. If this were the case, the results of our analyses would have been influenced in one way or another. It does not seem to explain, however, why it would cause a *decrease* in the proportion of interregional transactions.

Cause (2) might be partly due to the observed tendency in coastal areas, as several massive industrial agglomerations have actually been formed in some coastal regions such as the Pearl River Delta in Guangdong, Wenzhou in Zhejiang, and the Yangtze River Delta in the Central Coast. Industries are likely to have denser linkages with related industries within the cluster than with those outside the cluster. It follows that the relative amount of intraregional transactions to interregional transactions gets larger as the degree of intermediation gets higher (Wolf, 2000).

As for Cause (3), recent research on border effects are instructive. For instance, by estimating the border effects on China's intra- and international trade, Poncet (2003; 2004) pointed out that China's market fragmentation caused by local protectionism had been worsening during the 1990s. It is possible that artificial market fragmentation has generated a negative influence on the volume of interregional trade in China. If we relied solely on this explanation, one would conclude that China's distinctive reform strategies have had a strong influence on the pattern of spatial interactions between its spatial units; however this claim should be examined by further research that uses other data and methods.

Finally, it is important to note that the results and their interpretation depend crucially on how we aggregated the regional units in our analysis. By aggregating provincial administrative units into the seven major regions, we found that the intraregional linkages of many regions have intensified relative to the interregional linkages. If, however, we could have analyzed with more disaggregated spatial units, say at the provincial or county level, we might have been able to conclude that the interregional linkages (i.e. interprovincial or intercounty linkages) had been strengthened. Because data on interprovincial or intercounty trade is not available to us, we compute how a province has changed the degree of production specialization among provinces belonging to the same major region, in order to indirectly show the direction of changes in interprovincial linkages within a major region. Table 7 shows changes in the regional structural coefficient[11] of each major region over the period 1988 to 1997. We can see from Table 7 that the degree of specialization has risen during this period. Thus, if we assume that interindustry trade is the prevailing pattern of interprovincial trade present in China, then it follows that the degree of market integration within a major region has been reinforced through the growing amount of trade between the provinces which together constitute that major region. Given the present condition of

[11] The regional structural coefficient takes values between 0 and 1. The closer the coefficient of a major region is to 1, the more provinces in the major region specialize in terms of production. As for the definition of the regional structural coefficient, see World Bank (1994) pp.16–17. To compute the coefficients, we used values from the output of 36 (35 in 1994 and 1997) secondary industrial sectors in all provinces. These data are available in the *China Statistical Yearbook of Industrial Economy* (various years).

infrastructure, which is expected to impose quite large transaction costs on domestic trade, it might be realistic that the spatial integration of the Chinese economy takes place at first within relatively small geographical areas, such as the major economic regions that we use in this paper, gradually leading to the spatial integration of the whole national economy. All of the possible reasons stated so far will need to be carefully evaluated in our future research.

Table 7 Regional Structural Difference Coefficients

	1988	1991	1994	1997
Northeast	0.323	0.336	0.395	0.404
North China	0.230	0.236	0.252	0.296
Central Coast	0.190	0.203	0.229	0.210
South Coast	0.346	0.341	0.380	0.384
Central China	0.235	0.246	0.262	0.272
Northwest	0.328	0.350	0.396	0.413
Southwest	0.431	0.422	0.472	0.444
Simple Average	0.298	0.305	0.341	0.346

Source: National Bureau of Statistics, *China Statistical Yearbook of Industrial Economy* (various years), China Statistics Press.

4. Conclusion

The aim of this paper is to explore how the interdependencies between the economies of China's major regions have changed along with the deepening of reform. For this purpose, we computed some linkage measures and visualized structural changes in the interregional input-output linkages using Minimal Flow Analysis. Our analysis reveals that the interdependencies between regions have decreased; that is, the self-sufficiency of each regional economy has increased on average. This finding seems to favor the view that China's decentralized and gradual reform strategy has had a negative impact on the spatial integration of its economy; the implications of this finding, however, should be considered in further research using different data and/or analytical methods. The interpretation of our results depends on the way we aggregated the spatial units in our analysis. More important findings from our analysis are that some major changes have emerged in the structure of interregional linkages behind the tendency toward regional autarky. The Northeast, which used to have several important interregional linkages emanating from its heavy industry, has changed to become an economy that is rather isolated from other regions. The same is true in the Central Coast; that is, both regions have decreased in their importance as suppliers of intermediate goods to other regions. The Central Coast, however, has strengthened in intermediate supplies to the South Coast instead, and has continued to be a stable source of spillover effects to surrounding regions such as Central China. The South Coast has gradually become another growth center that receives several important linkages from a number of industries in other regions. North China and Central China have become self-sufficient, especially in manufacturing industries, and furthermore they have become important in supplying heavy-industrial and mining products to the Central Coast and the South Coast. All of these findings lead us to conclude that China is now experiencing the structural changes of economic interdependencies between its spatial units.

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Industrial Networks between China and the Countries of the Asia-Pacific Region

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Abstract

This paper investigates the changes in the structures of industrial networks that have occurred in the Asia-Pacific region in line with the rapid growth of the Chinese economy. Analyses using international input–output tables revealed that during the 1990s, there was a significant increase in the dependence of Asian countries' manufacturing industries, such as textiles and electronics, on China's industries, although as the main suppliers of industries in Asian countries, industries in Japan and the United States remain important.

Keywords: *qualitative input–output analysis, backward linkage, industrial network*

JEL Classification: D57, R15

1. Introduction

China succeeded in establishing the foundations for industrialization because, unlike other nations in Asia, it fostered heavy and chemical industries at a time when the country was still in a planned-economy phase. Since embarking on reforms and the open-door policy, the country has achieved economic development by encouraging the growth of labor-intensive types of manufacturing as the nation's leading export industries, thus demonstrating its comparative advantage in line with the transformation to a market economy. In the 1990s, China achieved economic growth at annual rates of almost double digits, a rate of expansion that was far higher than the rates of economic growth of other Asian countries.

During the course of establishing the foundations for heavy and chemical industries, China reformed its state-owned enterprises and introduced capital and technology from abroad, becoming both in name and reality a "world market" and a "world factory".

Where international trade is concerned, China (including Hong Kong) became the largest trading partner for Japan (in 2004), while Japanese firms have shifted the emphasis of their activities from ASEAN to China. In the meantime, China has moved ahead with a free trade agreement (FTA) with ASEAN, and in 2001 joined the WTO. China, moreover, has steadily raised its prominence within the Asian economy.

Recent years have seen the publication of many academic articles devoted to the study of China's strategies towards the formation of FTAs and economic integration in East Asia. Of particular interest is a series of studies that have stemmed from an intensive research project implemented by the Institute of Developing Economies (IDE). Contributions include those by Onishi ed. (2006), Hiratsuka ed. (2006) and Tamamura ed. (2007), which are distinguished by detailed case studies, theoretical interpretation, and analysis in the context of Japan–China relations respectively.

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What seems to be lacking in these studies, however, is that they fail to give a clear and comprehensive picture of the industrial reorganization in East Asia, a topic that is touched on only in the introduction of individual case studies and in the course of theoretical discussion. With this deficiency in mind, this paper aims to extract the characteristics of industrial networks in the Asia-Pacific region with special reference to the relationships between China and other Asian countries. More specifically, we will address the following two questions. First, is it possible to dynamically interpret the Chinese economy emerging in East Asia, and subsequent changes, by analyzing industrial networks? Second, is it possible to grasp quantitatively and comprehensively the implications for the East Asian region of the rise of the Chinese economy and the resultant reorganization of industry? In order to explore these questions, input–output analysis will be employed as our analytical framework. As our main data, we will use the Asian international input–output tables for the years 1990 and 2000, covering 10 countries and 16 industrial sectors.[1]

The structure of the paper is as follows. In Section 2, the emergence of China's industries in the economy of the Asia-Pacific region will be illustrated. In Section 3 and Section 4 the industrial networks within the region will be analyzed by using two different methodologies, namely Leontief multipliers and qualitative input–output analysis, respectively. The final section is devoted to an attempt to interpret the findings, albeit in hypothetical terms, of the empirical research that has been compiled.

2. Emergence of China's industries in the Economy of the Asia-Pacific Region

Before analyzing the structure of the linkages between China and other Asian countries, it is important to understand the relative importance of China's industries in the economy of the Asia-Pacific region. Normally, the share of gross domestic product (GDP) or trade volumes of a country in the region is used to evaluate the relative importance of a country (or an industry) in the region's economy. In this paper, the significance of China's industries will be evaluated by measuring the influence of China's industries on the gross output of the region, an objective that cannot be achieved by using conventional methods. In order to measure the influence of China's industries on the economy of the Asia-Pacific region, the hypothetical extraction method (HEM) is employed. The basic concept of the HEM will first be introduced, and the results will then be discussed.

2.1 Hypothetical Extraction Method

The basic idea of HEM was originally presented by Strassert (1968) and Schultz (1976, 1977). Suppose that there exist two regions (1 and 2) and n industries. The basic interregional input–output model can then be expressed as follows:[2]

$$X = (I - A)^{-1} F \quad (1)$$

[1] See Appendix 1 for the sector description.

[2] There are several variations in HEM. For detailed discussions, see Miller and Lahr (2001). In this paper, the variation of "Case 1" in Miller and Lahr (2001) is employed.

where

$$\underset{2n\times 1}{X} = \begin{pmatrix} X^1 \\ X^2 \end{pmatrix}; \quad \underset{2n\times 2n}{I} = \begin{pmatrix} I_n & O \\ O & I_n \end{pmatrix}; \quad \underset{2n\times 2n}{A} = \begin{pmatrix} A^{11} & A^{12} \\ A^{21} & A^{22} \end{pmatrix}; \quad \underset{2n\times 1}{F} = \begin{pmatrix} F^1 \\ F^2 \end{pmatrix}$$

To measure the influence of industries in region 1, we define an augmented matrix that extracts all three sub-matrices in which region 1 has an influence:

$$A^e = \begin{pmatrix} O & O \\ O & A^{22} \end{pmatrix} \tag{2}$$

The hypothetical output in which the industries in region 1 do not exist thus becomes:

$$X^e = (I - A^e)^{-1} F \tag{3}$$

where

$$X^e = \begin{pmatrix} X^{1e} \\ X^{2e} \end{pmatrix}$$

From (1) and (3), the change (decrease) of output by extracting the industries in region 1 is calculated as:

$$\Delta X = X^e - X = [(I - A^e)^{-1} - (I - A)^{-1}]F \tag{4}$$

ΔX is the decrease of gross output when country 1 is taken as not existing in the region and thus indicates the magnitude of impact of country 1 on the region's economy. Therefore, by calculating the values of (4) for each member country of the Asian table, the influence of China's industries on the economy in the region can be evaluated.

2.2 Results

The results calculated via the HEM, defined by (4), for 1990 and 2000 are reported in Table 1. The column "Country extracted" indicates that the country has been removed from the system in the manner shown in (2). The column "Change of other countries' output" indicates the percentage changes in total output of the other nine countries when the country in the left-hand column is eliminated. For example, in 1990, the output of the nine Asian countries shown in the table falls by 1.581% when the entire industrial activity of the United States is removed.

From the results presented in Table 1, two major facts can be observed as regards changes in industrial linkages in the Asia-Pacific region. First, overall linkages among the countries of the region strengthened between 1990 and 2000. It can be seen from the results reported under "all industries" that the impact of each country's industries (except those of Japan) on other member countries increased from 1990 to 2000. Second, there was a strengthening in the influence of China's industries on other countries' outputs. The impact of the category "all industries" of China on other member countries' output increased by nearly four times from 1990 (0.166%) to 2000 (0.653%), this being the highest rate of growth among the Asian countries listed in the table. China's ranking also climbed, from seventh in 1990 to third in 2000. The same trend can be observed at industry level. During the 1990s, China's electrical goods and electronics industry, in particular, significantly increased its importance in the economy of the Asia-Pacific region, as can be seen from its impact on other member countries' output, which increased from 0.033% in 1990 to 0.229% in 2000. Third, another important result is that by 2000, the influence of China's textile industry on other countries exceeded that of Japan. It is obvious from Table 1 that the influence of the United States and Japan on the economies of the Asia-Pacific region is outstanding in every industrial category. However, in 2000, the impact of China's textile industry was double that of Japan's, a sharp contrast with the situation in 1990.

To sum up, while there was a strengthening in industrial linkages among all the countries of the Asia-Pacific region, the relative importance of China's industries in the region increased significantly during the 1990s. In particular, China's textile industry has come to play a major role in the region.

3. Industrial Linkages between China and Asian Countries

The results of the application of HEM clearly showed the increase during the 1990s in the relative importance of China's industries in the economy of the Asia-Pacific region. In this section, changes in the structure of the linkages between China and other Asian countries—linkages that underlie the rapid expansion of China's industries—will be explored in detail.

Although trade volumes are often used to capture the structure of international linkages among industries (see for example Voon, 1998; and Ernst and Guerrieri, 1998), linkage structures can also be formed through other channels such as foreign direct investment and technology transfers, and the effects of these activities will be reflected in the structures of production. It follows that international trade flows can describe only limited aspects of international industrial linkages. To overcome such limitations in the conventional methods, this section attempts to identify the characteristics of industrial networks by calculating Leontief multipliers. We will focus in particular on three important industries, namely the textile industry, electrical goods and electronics manufacturing, and the transport equipment industry.

3.1 Methodology

Measuring backward linkage effects

In the literature, various linkage measures have been proposed to identify the sectors important for economic development.[3] These measures include: (1) direct input coefficients (Chenery and Watanabe, 1958; Yotopoulos and Nugent, 1973), (2) Leontief multipliers (Rasmussen, 1957), (3) the variability index (Rasmussen, 1957), and (4) the hypothetical

[3] Although there are two kinds of linkage effects, namely forward linkage effects and backward linkage effects, we will confine our attention to backward linkage effects as the forward linkage effect measured from input-output analysis is based on unrealistic assumptions.

extraction method (Strassert, 1968; Shultz, 1977; Miller and Lahr, 2001). This paper employs the Leontief multiplier as it is the most intuitive of the methods available and allows the construction of diagrams of the industrial linkages among Asian countries. The definition of the Leontief multiplier is as follows:

$$L_j^{rs} = \sum_i b_{ij}^{rs} \qquad (5)$$

where b_{ij}^{rs} is the element of the inverse matrix $(I-A)^{-1}$, i and j denote industries ($i, j = 1,2,\cdots,n$) and r and s are regions (countries). Therefore, L_j^{rs} can be interpreted as the "interregional backward linkage effect" of industry j in region s on industries in region r. More intuitively, the Leontief multiplier indicates the required level of industrial output in region r when one unit of additional final demand occurs in industry j in region s. The share of L_j^{rs} to the total backward linkage effect can thus be calculated as:

$$l_j^{rs} = \frac{L_j^{rs}}{L_j^{s}} = \frac{\sum_i b_{ij}^{rs}}{\sum_r \sum_i b_{ij}^{rs}} \qquad (6)$$

Diagrammatic expressions of backward linkage effects

In order to capture the characteristics of the structure of linkages among the industries of the countries in the Asia-Pacific region, the backward linkage effects defined in (6) can also be illustrated diagrammatically as in Figure 1.

Figure 1 Diagrammatic Expression of Backward Linkage Effects

(Textile Industry)

In the diagram, which illustrates the case for the textile industry, a broken arrow extends from country A to country B. The percentage figures in parentheses under the country names represent the share of demand that can be met by domestic industries when one extra unit of final demand occurs in the textile industry in that particular country. In the above example, 86.5% of induced demand can be satisfied by industries in country A when one unit of additional final demand to the textile industry occurs. The remaining 13.5% of induced demand must be satisfied by industries in other countries. In the above example, between 3% and 5% of the induced demand is satisfied by industries in country B. The arrow is drawn as a fine solid line when the rate of dependency on country B is between 5% and 10%, and takes the form of a thick solid arrow when the dependency rate is more than 10%.

These diagrammatic expressions of backward linkage effects provide us with very useful information. First, the degree of concentration of arrows identifies the international division of labor in the Asia-Pacific region. A country with many outgoing arrows is highly dependent on other countries' industries to satisfy induced demand. On the other hand if a country has many incoming arrows, the industries in that country function as suppliers to industries in other countries. Second, the changes of directions and thickness of the arrows from 1990 to 2000 tell us how the structures of the linkages among the countries of the region have changed over time. Thus diagrammatic representations of the kind shown in Figure 1 can be a powerful tool for extracting the characteristics of the structures of the inter-country linkages in particular industries.

3.2 Results

The calculation results of l_j^{rs} for selected industries are summarized in Appendix 2. The diagrammatic expressions of these results are presented in Figures 2, 3, 4 and 5.

All industries

As an illustration of the overall trend, Figure 2 portrays the structure of linkages in all industries in the region. The figure illustrates the existence of the following three features. First, in 1990, industries in Asian countries were highly dependent on industries in Japan and the United States, and in the diagram these two countries were the major destinations of arrows from Asian countries. The dependency on Japan is especially remarkable. Second, examination of the two diagrams shows that the dependence on Japan and the United States remained much the same even in 2000. Third, in both the 1990 and 2000 sections of the diagram, there are no incoming or outgoing arrows to or from China, which shows that in both of these years China's industries did not have strong linkages with industries in any other country of the Asia-Pacific region. As is shown in the figures in parentheses, China's industries are highly self-sufficient and most of the demand for industrial products is satisfied by domestic industries. This reflects the economic structure that was formed during the closed period of the planned economy that prevailed until 1978. Figure 2 leads us to conclude that the structure of industrial linkages within the Asia-Pacific region is robust and that no significant changes occurred during the 1990s.

However, such aggregate pictures may mask important structural changes at individual industry level, and it is to this aspect that the discussion now turns.

Textile industry

Figure 3 shows the regional structure of linkages in the textile industry. In the 1990 part of the diagram, Japan, the United States and Taiwan attract many arrows from other Asian countries. This indicates that the Asian countries depended on suppliers in Japan, the United States and Taiwan to satisfy their textile industry demand. In other words, these three countries functioned as suppliers (directly and indirectly) to textile industries in other Asian countries. By 2000, however, this structure had changed. In the 2000 section of the diagram, there are fewer arrows going to Japan and Taiwan than there were in 1990, while China became a major destination of arrows from many Asian countries. This indicates that in many Asian countries, textile manufacturers switched from Japanese and Taiwanese suppliers to Chinese ones. For example, in 1990, the Philippines textile industry depended heavily on suppliers in Japan (5.0%), the United States (7.9%) and Taiwan (9.1%) to satisfy induced final demand, while its dependence on Chinese suppliers was only 1.0%. However, by 2000, its dependence on Japan and the United States had dropped significantly (to 4.0% and 4.4%, respectively) whereas its dependence on China had increased to 4.3%. This implies that during the ten-year period, China had begun to replace Japan and the United States as a major supplier to the Philippines' textile industry.

Electrical goods and electronics industry

The electrical goods and electronics industry presents a picture (see Figure 4) that differs from that of the textile industry. In 1990, the network structure of the electrical goods and electronics industry was simple, in that in the Asian countries the industry was highly dependent on Japan and the United States to satisfy the demand induced by the final demand for electrical products in each country. Although some countries such as the Philippines, Malaysia and Thailand also depended on electrical industries in Singapore, the magnitudes of dependency were small compared with Japan and the United States.

The diagram for 2000 shows that there were three points worthy of mention which occurred after 1990. First, the network structure that existed in 1990 was basically the same in 2000. This can be seen in the diagram, in which many countries extend arrows to Japan and the United States in both the 1990 and 2000 sections. A second feature of the diagram is that, in addition to Japan and the United States, countries such as the ROK and China emerged as new destinations for the arrows from other Asian countries. Third, the share of dependence on domestic industries dropped in most of the Asian countries. This implies progress in the diversification of procurement throughout the Asia-Pacific region. Electrical goods and electronics industries in Japan and the United States remained major suppliers to their counterparts in Asian countries, but diversification of procurement has progressed in many Asian countries, while the ROK and China have also emerged as suppliers by replacing the domestic industries of other countries. As a result, the linkage structure within the region has become more complex.

Transport equipment industry

Among the three industries analyzed in this section, the transport equipment industry shows the most stable linkage structure. In the diagram, in 1990 Japan and the United States were the only destinations for arrows. The dependency on industries in Japan is especially conspicuous, as is shown by the thick solid lines that show a dependency rate of more than 10% of total induced demand. These extended from most of the countries in 1990. In 2000 many countries had come to depend not only on industries in Japan but on industries in the United States, but the dependency mostly on industries in Japan and the United States is the same as in 1990. In contrast with the other two industries analyzed, the Chinese transport equipment industry has not functioned as a supplier to other Asian countries. This may suggest that while Chinese manufacturing is capable of accommodating the technologies of the textile and electronics industries, it is not quite so advanced in the case of the transport equipment industry, which requires a higher level of technological development than the other two industries.

3.3 Summary

This section has attempted to sketch the main characteristics of the linkage structures of selected industries in the Asia-Pacific region by measuring backward linkage effects. The major findings can be summarized as follows.

The measurement of backward linkage effects identified some important features regarding industrial networks in the Asia-Pacific region. First, the results for industry overall revealed a robust linkage structure, which we have taken as having remained in place throughout the 1990s, in which industries in most of the Asian countries are highly dependent on industries in Japan and the United States to meet domestic demand. The analyses at the level of individual industries, however, revealed different patterns.

Textile industry: Between 1990 and 2000, the textile industries in the Asian countries shifted their dependence from industries in Japan and the United States to those in China.

Electrical goods and electronics industry: The electrical goods and electronics industries in Asian countries diversified their suppliers. While in 1990 the electronics industries in all of the Asian countries depended only on the industries in Japan and the United States, in 2000 the industries in the ROK, China and Singapore emerged as suppliers rather than as merely domestic manufacturers. This implies progress in the international division of labor in electrical goods and electronics manufacturing, and as a result, the network structure within the region has become more complex.

Transport equipment: A robust linkage structure in 1990 in which Asian transport equipment industries were highly dependent on their counterparts in Japan and the United States remained in place in 2000. In 2000, some shifts in dependence from Japan to the United States became apparent, but the diagrams showed little change between 1990 and 2000 relative to the diagrams for the other two industries. China does not play a significant role as a supplier in this industry.

That said, the industry level analyses suggest a change in the role of China's industries in the industrial networks of the Asia-Pacific region. Along with its emergence as a production base, China rapidly increased its importance as a supplier to the textile and electronics industries in other Asian countries. China, however, does not possess a sufficiently high level of technology to supply the transport equipment industry and thus transport industries in Asian countries have continued to depend on Japan and the United States. For industries in China, therefore, technological upgrading will thus be an important prerequisite for further development.

4. Qualitative Input–Output Analysis

In Section 3, the industrial networks of some selected industries in the Asia-Pacific region were revealed by measuring backward linkage effects. In this section, we will attempt to extract the industrial networks by using an alternative methodology, namely qualitative input–output analysis (QIOA). Analyses employing two different methodologies will provide us with a more robust and comprehensive picture of Asia's industrial networks.

4.1 Methodology

We use the methodology of QIOA introduced by Aroche-Reyes (1996) to identify the structure of spatial input–output linkages. QIOA aims to reveal the underlying structure of an input–output table by identifying the intermediate transactions that are important. The step-by-step methodology of our analysis can be presented as follows:
(1) Identify "important cells" in the technical coefficient matrix using a mathematical formula. (2) Convert the technical coefficient matrix into a corresponding binary matrix (i.e. an adjacency matrix), in which the entries of the important cells take a value of unity and the unimportant ones, zero. The adjacency matrix shows a structure of important linkages but at the same time it only shows which sectors are directly linked together through the important linkages. (3) Take indirect linkages into consideration, too. Suppose that there exist important transaction flows from sector *j* to sector *k*, and from sector *k* to sector *l*. Therefore the linkages from sector *j* to sector *k* and from sector *k* to sector *l* are identified as important. Then suppose that there also exists an important linkage from sector *j* to sector *l* (via sector *k*). We also take into account such indirect linkages using a graph theoretical method. (4) Obtain a total structure of important linkages by taking both directly and indirectly important linkages into consideration. Compare the structures at different time points to elucidate how the skeleton of spatial input–output linkages has changed during the period of analysis.

We begin with a formula that can be used to identify important cells in the technical coefficient matrix *A*. Following Aroche-Reyes (1996), we adopt a formula introduced by Schintke and Stäglin (1988) and Jilek (1971). The formula aims at finding important cells in *A*, judging by the impact on the elements of the Leontief inverse matrix when an element in *A* changes in a given proportion. The tolerable limit r_{ij} of change in each technical coefficient a_{ij} is computed by the following equation, so that the output in any related sector varies at most by 1%, while final demand remains fixed:

$$r_{ij} = \frac{100}{a_{ij}[b_{ji} + 100(b_{ii}/\tau_i)\tau_j]} \tag{7}$$

where b_{ji} denotes the corresponding entry in the Leontief inverse matrix, and τ_i and τ_j denote the gross output of sectors *i* and *j* respectively. If the technical coefficient a_{ij} increases by more than the tolerable limit r_{ij} , then output in a related sector will increase by more than 1%. Therefore the smaller r_{ij} , the smaller the change in a_{ij} required to have large effects on the output of related sectors. We identify such entries as important cells (or to put it differently, the linkage from sector *i* to sector *j* is held to be important). Conventionally an entry in *A* is identified as important when r_{ij} is not greater than 20% (Aroche-Reyes, 1996, 2002; Ghosh and Roy, 1998).

Next, we turn to the equation:

$$(I - A)^{-1} = A^0 + A^1 + A^2 + A^3 \cdots \tag{8}$$

where $A^0 \equiv I$. We convert each matrix layer A^i ($i = 0, 1, 2, \cdots$) to the corresponding adjacency matrix W^i ($i = 0, 1, 2, \cdots$). The conversion of A into W is implemented based on the following equation:

$$w_{ij} \begin{cases} = 1, & if \quad r_{ij} < 20 \\ = 0, & if \quad r_{ij} \geq 20 \end{cases} \tag{9}$$

where $W = (w_{ij})$ and r_{ij} is the tolerable limit of change for a_{ij} defined by Equation (7). For a layer of which the order is higher than 2, the following equation (10) is applied to convert A^k into W^k.

$$W^k = W^1 W^{k-1} \tag{10}$$

The last step is to obtain the qualitative Leontief inverse matrix Ψ. The derivation of the matrix is based on the following equation, (11):

$$\Psi = W^0 + W^1 + W^2 + W^3 + \cdots \tag{11}$$

where $W^0 = I$. Note that the matrix multiplications in (10) and the summation of W^k in (11) should be done in Boolean fashion. An entry Ψ_{ij} in Ψ will be unity if sectors i and j are connected through a path, regardless of the number of steps needed to go from i to j (Aroche-Reyes, 1996). We regard them as important among all the linkages in the following analysis. The resulting structures of important linkages will be shown in diagrams in the next section.

It is worthwhile pointing out that we work with layers derived from the technical coefficient matrix A, not with layers derived from the intermediate transaction matrix Z. In other words, in this present analysis, we concentrate mainly on the technical relationship between production sectors. The latter approach arose from the Minimal Flow Analysis introduced by Schnabl (1994), in which the volume and structure of final demand is also taken into consideration.[4]

4.2 Findings

4.2.1 The Number of Important Cells

The results of the calculations are presented in Table 2. As shown in Table 2, the number of important cells in all regions fell from 912 in 1990 to 854 in 2000, a decline that was accompanied by a fall over the same period in the number of important cells in interregional transactions from 162 to 142. According to the results of backward linkage effects conducted in studies such as Meng et al. (2006), the degree of interregional dependence increased over time in each country, and the influential coefficient within some countries increased. These facts may suggest that the number of important cells fell because those exclusively linked to particular sectors were linked to more than one sector. On the other hand, the number of important cells in the manufacturing sector, which are reported in Table 3, increased from

[4] For this application, see Hioki et al. (2005) and Okamoto and Tamamura (2005).

53 to 73. This implies that the technical relationship among production sectors in Asia has strengthened, though the number of important cells as a whole has fallen.

China has by far the greatest number of important cells, its total having increased from 133 in 1990 to 135 in 2000 (Table 2), and the linkage within China itself is fairly strong. In this connection, it is also significant that the backward linkage effects of China are greater than those of any other Asian country (Meng et al., 2006).

Japan also has a large number of important cells, and in addition the number of incoming linkages with Japan as a recipient of the linkages is larger than in any other country: 79 in 1990, and 51 in 2000. The United States accounts for the second largest number of incoming linkages. We can see here a structure in which various countries depend on the intermediate goods of Japan and the United States as recipients of the linkages in the Asia-Pacific region. Even so, the trends exhibited by these two countries are somewhat different. While the proportion of incoming linkages for Japan fell from 50.3% to 38.6% over the ten years, the figures for the United States remained more or less constant over the same period, falling only slightly from 44 to 42 linkages. The degree of dependence of the Asia-Pacific countries on Japan has been declining.

So far as outgoing linkages are concerned, both Malaysia and Singapore provided, as of 1990, around 40% of their total linkages to other countries. In 2000 the outgoing linkages in the total linkages of five countries other than the ROK, Japan and, the United States were in the range 23.9% to 37.6%. This allows us to conclude that the regional linkages among Asian countries have weakened during the period in question.

4.2.2 Networks among Countries

Figure 6 shows the networks of individual countries, and has been drawn up on the basis of Table 2. It is apparent that in 1990, China and the other Asia-Pacific countries with the exception of the ROK and the United States depended on Japan. By contrast, Taiwan and ASEAN except for Indonesia depended on the United States. The figure also shows an Asian network consisting of the Philippines → Singapore → Indonesia / Thailand, and another network among the ASEAN countries consisting of Singapore → Malaysia → Thailand.

In 2000, the number of countries having networks dependent on Japan had fallen, and consisted of only Indonesia, Malaysia, the Philippines and Taiwan. In the meantime, the ROK and Indonesia began to depend on the United States. The technological linkages concerning intermediate manufactured goods had shifted from Japan to the United States. Indonesia increased its dependency on Malaysia, as well as on the two Northeast Asian countries of the ROK and China. Among the ASEAN states, two networks can be seen: one consisting of Indonesia / the Philippines / Thailand → Malaysia, and the other of Indonesia / Thailand → Singapore, indicating an increasing presence of Malaysia and Singapore as recipients of linkages.

4.2.3 Networks of the Manufacturing Sector in Asian Countries

Figures 7 through 10 show networks in terms of each manufacturing sector. The following notable features characterized the situation in 1990: (1) each country depended on various intermediate goods produced by the manufacturing sector in Japan; and (2) a wide range of manufacturing sectors in Taiwan, the Philippines, Malaysia and Singapore depended on electrical and electronic intermediate goods supplied by the United States.

The metal products, electrical goods and electronics and other manufacturing sectors in Taiwan depended on products supplied by the Japanese electrical goods and electronics industry, and the same is true of the transport equipment industry. As for Indonesia, its various manufacturing sectors, metal products, and machinery sectors depended on three industries in Japan, namely food processing, metal products, and machinery. The food processing, chemicals, and machinery sectors in Malaysia rely on intermediate goods supplied by various light industries in Japan. It can also be seen that the Singaporean metal products sector is dependent on goods supplied by Japanese industries such as chemicals, machinery, and transport equipment. Sectors dependent on the US electrical goods and electronics industry include metal products, and electrical goods and electronics in Taiwan; metal products, electrical goods and electronics manufacturing in the Philippines; six categories—ranging from non-metallic mineral products to other manufacturing sectors—in Malaysia; and the non-metallic mineral products, metal products, electrical goods and electronics, and transport equipment industries in Singapore.

Notable features in 2000, on the other hand, are: (1) increased concentration in the electrical goods and electronics sector among industries dependent on Japanese suppliers; (2) heightened linkages of various ROK industrial categories to the US electrical goods and electronics sector; (3) linkages to the electrical goods and electronics industry in Singapore and Malaysia are heightened within ASEAN; and (4) dependence on Chinese manufacturers of various Indonesian light industries, and of the textiles sector in Taiwan.

Several linkages disappeared during the ten years between 1990 and 2000. These included the dependence of the Philippine metal products sector on Japanese metal products and machinery manufacturers; dependence of the Malaysian food processing, metal products, and machinery sectors on Japanese light manufacturing; and the dependence of the Singaporean chemical sector on the Japanese chemicals, metal products, transport equipment, and other manufacturing categories.

On the other hand, the other light manufacturing, chemicals, and non-metallic mineral products sectors of Taiwan have come to rely on Japanese and US electrical goods and electronics suppliers, while the chemicals, non-metallic mineral products, metal products, electrical goods and electronics, and other manufacturing sectors of the ROK began to depend on US manufacturers of electrical goods and electronics, and accordingly there has emerged a concentration of linkages to the electrical goods and electronics sectors of Japan and the United States.

The ASEAN countries as a whole have come to rely on the metal products and the electrical goods and electronics sectors in the Philippines, on the machinery industry in Indonesia and on electrical goods and electronics manufacturing in Malaysia—that is, a mutual dependence has arisen. The machinery sector in Indonesia began to rely on electrical goods and electronics suppliers in Singapore, and the electrical goods and electronics sectors in Malaysia and Singapore are linked to each other.

As for China, its machinery industry was dependent on the Japanese chemicals sector in 1990, but, by 2000, this linkage had disappeared. On the other hand, other light manufacturing in Indonesia came to depend on China's food processing, other light manufacturing, chemicals, non-metallic mineral products, and electrical goods and electronics suppliers, while the chemical industry of Taiwan began to depend on the Chinese textiles sector, and the textiles sector of Taiwan was linked to the textiles, chemicals and other manufacturing categories in China.

Let us now consider the stable networks of the Asia-Pacific region. Stable networks may affect production unless intermediate goods produced in other countries are made use of technically; this suggests the presence of closer or more important technical linkages.

So far as sectors dependent on Japan are concerned, the metal products, electrical goods and electronics, and other manufacturing sectors of Taiwan depend on the Japanese electrical goods and electronics industry, and the other light manufacturing and metal products sectors of Indonesia rely on several manufacturing sectors in Japan.

Meanwhile, the metal products and electrical goods and electronics sectors of Taiwan, the Philippines, Malaysia and Singapore are all linked to the US electrical goods and electronics industry.

The electrical goods and electronics industries of Malaysia and Singapore are mutually dependent, and are also linked to a number of other industrial categories.

4.2.4 Summary

The findings from the QIOA described above can be summarized as follows.

- Linkages among manufacturing sectors have certainly strengthened. Manifestations of this include the dependence of ROK sectors on their US counterparts, and the reliance of Indonesian manufacturing and Taiwanese industry on China.
- The focus of the linkages of the manufacturing sectors is beginning to shift from Japan to the United States. Some sectors in Malaysia, the Philippines and Singapore have registered a reduction in the degree of their dependence on Japan.
- Among the ASEAN member states, the linkage between Singapore and Malaysia is intimate; it can be said that a strong interdependence has emerged between the electrical goods and electronics industries of the two countries.
- There are few linkages indicating China's dependence on other manufacturing countries. Rather, Taiwan and Indonesia have begun to create dependent linkages with China.
- The nucleus of the pattern of linkages in the manufacturing sectors is provided by the electrical goods and electronics industry, in which Japan and the United States play the central roles.

5. Conclusions

The development of the Chinese economy has been in many ways unique. Other countries in Asia—whose primary post-war task was to achieve their decolonization and to break away from their monoculture economies—succeeded in industrialization via export-oriented strategies, and shifted their focus from the export of primary products to labor-intensive processing and assembly-line industries where they enjoyed comparative advantage. For the economic development of these countries, the import of intermediate goods from Japan was indispensable, and the US market was also necessary for the success of manufactured exports. This process of development is called the "East Asian model." China, on the other hand, embraced large-scale projects with the assistance of the former Soviet Union, and promoted the industrialization of the heavy and chemical sectors when the Chinese Communist Party came to power shortly after the Second World War. China also rapidly strove towards self-sufficient development of the heavy and chemical industries through the Third Front construction program. Following the reforms of Deng Xiaoping and the adoption of the "Open Door" policy, China began to follow the East Asian model of development, promoting labor-intensive processing and assembling industries—where foreign-owned companies located in special economic zones, as well as local firms in the coastal areas, have been able to equally benefit from comparative advantage. This trend was reinforced through the adoption of the "Coastal Area Development Strategy" in 1987. After 1990, the Chinese economy underwent rapid growth and exports increased rapidly. Because China has successfully developed its labor-intensive industries while retaining heavy and chemical types of manufacturing, it will have considerable opportunities for further economic development in the future so long as it can manage to strike a balance between the heavy and the light industrial sectors.

The process of self-sufficient industrialization is clearly reflected in the findings of our analysis. In 1990, China's important linkages were all contained within the country. With its vast land area, the export strategy deployed in some coastal areas did not immediately lead to the creation of linkages overseas. Linkages affecting production lay within domestic industries only.

By 2000, however, the situation had begun to change substantially. Chinese industries were now technologically important for Taiwanese textile production and for other categories of light manufacturing in Indonesia. These changes suggest that the level of industrial technology in China is now superior to that of Indonesia, a country which is relatively backward by comparison with the rest of ASEAN. Moreover, Chinese industrial technology became necessary for labor-intensive industries in Taiwan as a result of the large amounts of investment in China.

In Asia as a whole, the electrical goods and electronics industry lies at the center of manufacturing networks. Since the technological levels of Japan and the United States in this sector are superior, the electrical goods and electronics industries in other countries need to import electronic components with high value added from these two developed countries. On the other hand, Singapore and Malaysia, while depending on Japan and the United States, manufacture electrical goods and electronics components using their medium-level technologies, and serve as a core at the other extreme of the industrial networks.

The Information Technology Outlook 2006 published by OECD reports that exports of IT-related goods and services from China exceeded those from Japan and the EU in 2003, and those from the United States in 2004, so that China became the largest supplier in the world (evening edition of *Nihon Keizai Shimbun*, October 23, 2006). Since China focuses on added-profit trade, it may already have been integrated into the industrial networks linked to the Japanese and US electrical goods and electronics industries, or to the same industries in Malaysia and Singapore.

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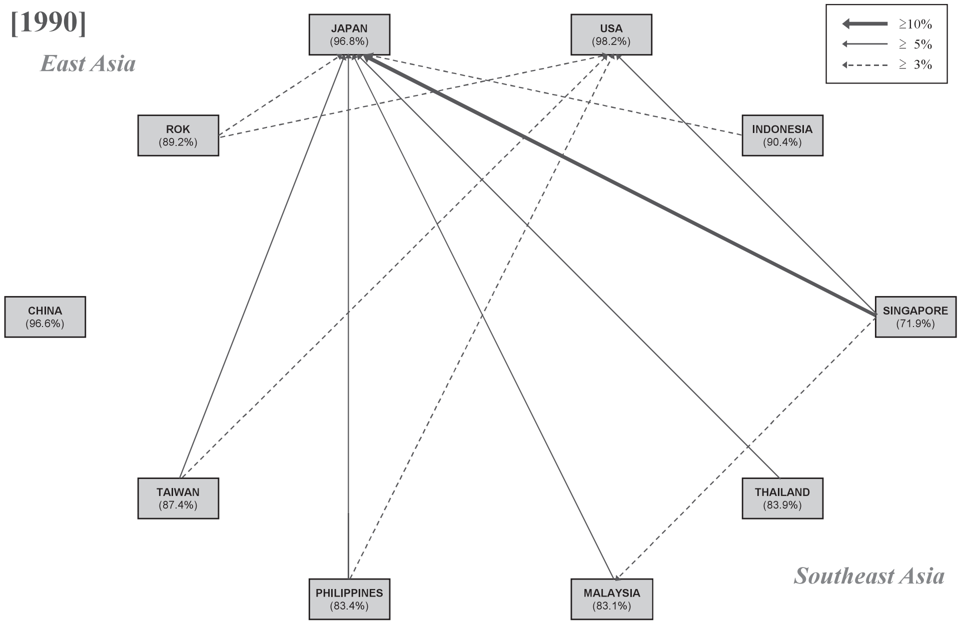
Table 1 Results of HEM

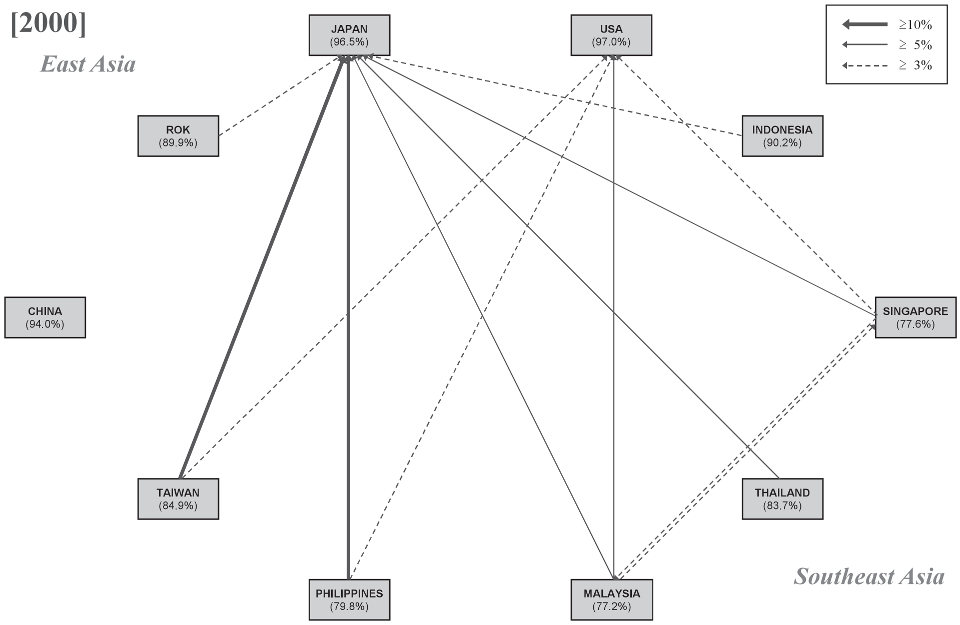
1990			2000		
Rank	**Country extracted**	**Change of other countries' outputs**	**Rank**	**Country extracted**	**Change of other countries' outputs**
[All industries]					
1	USA	-1.581%	**1**	USA	-2.514%
2	Japan	-1.121%	**2**	Japan	-0.914%
3	ROK	-0.350%	**3**	China	-0.653%
4	Taiwan	-0.280%	**4**	ROK	-0.426%
5	Singapore	-0.221%	**5**	Taiwan	-0.405%
6	Thailand	-0.168%	**6**	Malaysia	-0.310%
7	China	-0.166%	**7**	Singapore	-0.251%
8	Malaysia	-0.101%	**8**	Thailand	-0.189%
9	Indonesia	-0.075%	**9**	Philippines	-0.112%
10	Philippines	-0.061%	**10**	Indonesia	-0.079%
[Textile industry]					
1	USA	-0.091%	**1**	USA	-0.010%
2	Japan	-0.077%	**2**	China	-0.071%
3	ROK	-0.043%	**3**	Japan	-0.036%
4	China	-0.036%	**4**	ROK	-0.032%
5	Taiwan	-0.027%	**5**	Taiwan	-0.025%
6	Thailand	-0.026%	**6**	Thailand	-0.019%
7	Philippines	-0.017%	**7**	Indonesia	-0.016%
8	Indonesia	-0.017%	**8**	Malaysia	-0.015%
9	Malaysia	-0.016%	**9**	Philippines	-0.012%
10	Singapore	-0.013%	**10**	Singapore	-0.008%
[Electronics industry]					
1	USA	-0.317%	**1**	USA	-0.706%
2	Japan	-0.192%	**2**	Japan	-0.276%
3	Philippines	-0.177%	**3**	China	-0.229%
4	Singapore	-0.114%	**4**	Taiwan	-0.225%
5	ROK	-0.105%	**5**	Malaysia	-0.202%
6	Taiwan	-0.090%	**6**	ROK	-0.195%
7	Thailand	-0.042%	**7**	Singapore	-0.151%
8	Malaysia	-0.041%	**8**	Thailand	-0.089%
9	China	-0.033%	**9**	Philippines	-0.065%
10	Indonesia	-0.011%	**10**	Indonesia	-0.014%
[Transport equipment]					
1	USA	-0.323%	**1**	USA	-0.561%
2	Japan	-0.115%	**2**	Japan	-0.113%
3	ROK	-0.050%	**3**	China	-0.058%
4	Thailand	-0.041%	**4**	ROK	-0.054%
5	Taiwan	-0.035%	**5**	Taiwan	-0.032%
6	China	-0.026%	**6**	Thailand	-0.030%
7	Indonesia	-0.021%	**7**	Malaysia	-0.017%
8	Singapore	-0.017%	**8**	Indonesia	-0.014%
9	Malaysia	-0.015%	**9**	Singapore	-0.013%
10	Philippines	-0.010%	**10**	Philippines	-0.011%

Source: Calculated from the *Asian International Input–Output Tables* for 1990 and 2000.

[Figure 1 appears within the text, in Section 3.1]

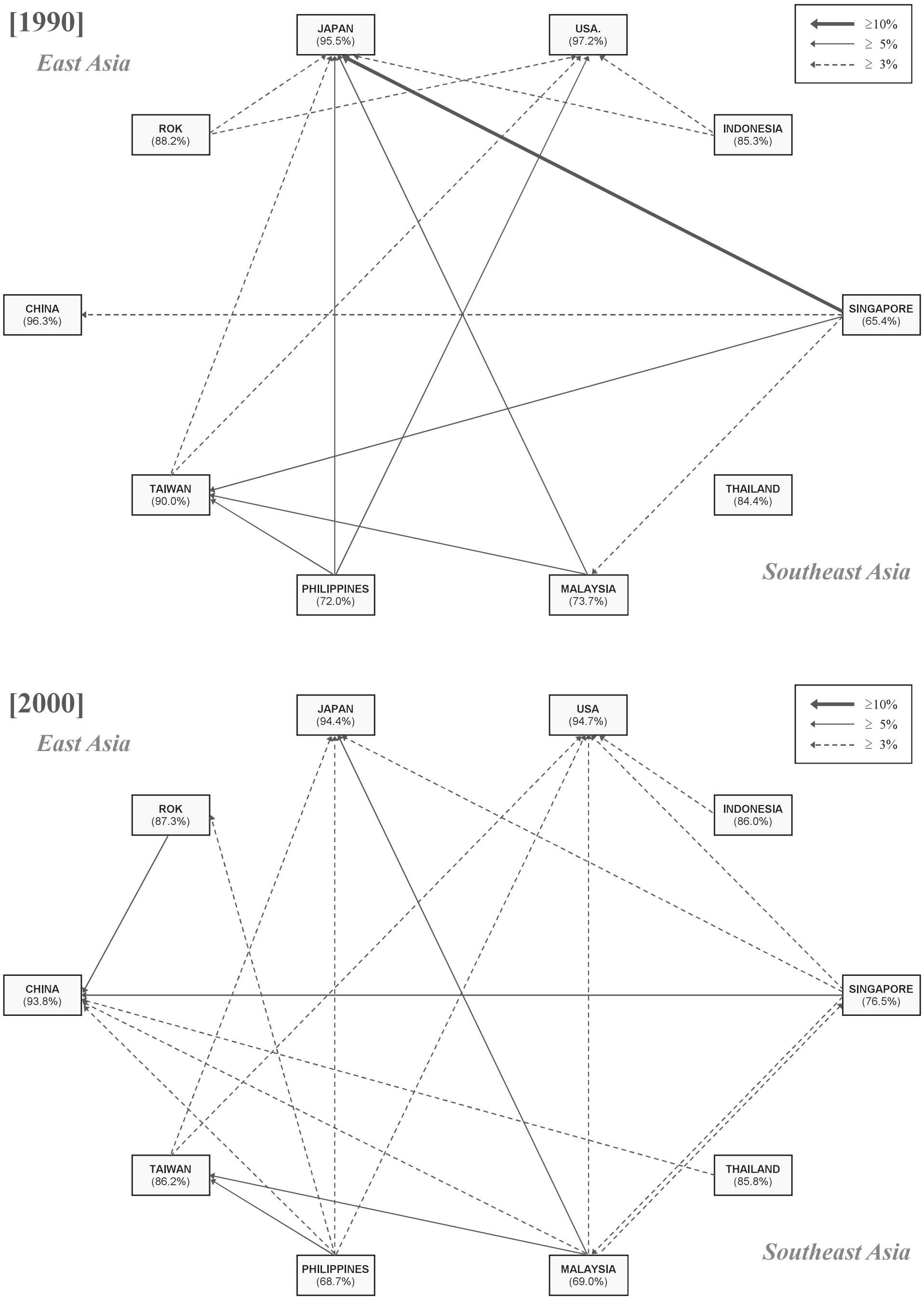
Figure 2 Linkage Structures (All Industries)





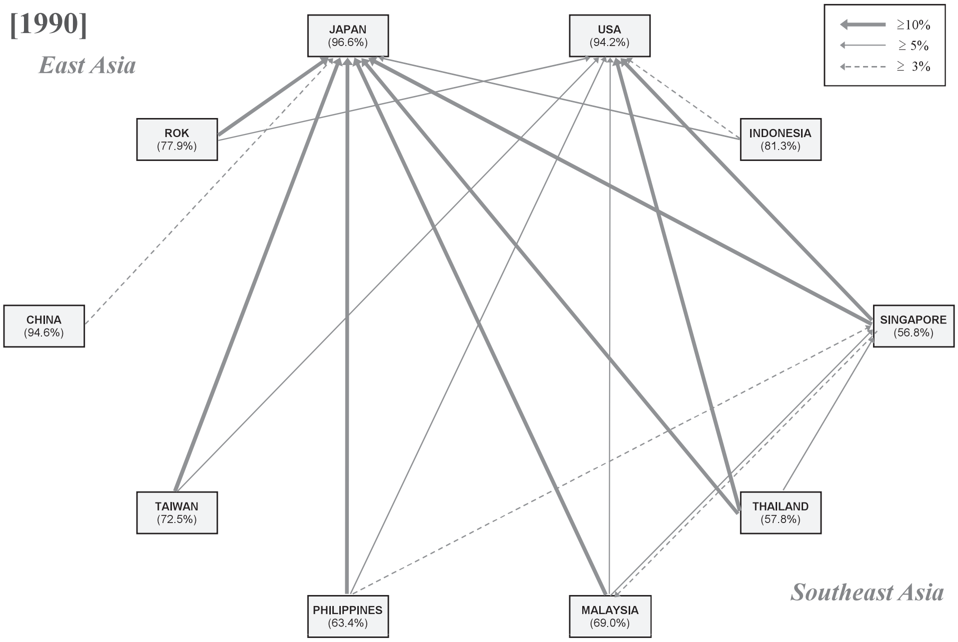
Sources: Calculated from the *Asian International Input–Output Tables* for 1990 and 2000.

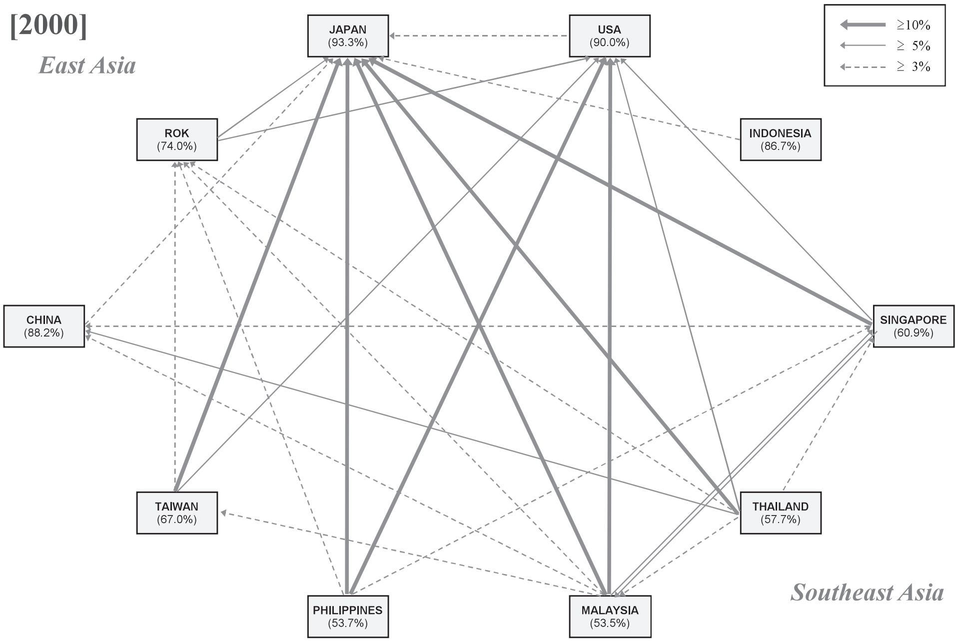
Figure 3 Linkage Structures of the Textile Industry



Sources: Calculated from the *Asian International Input–Output Tables* for 1990 and 2000.

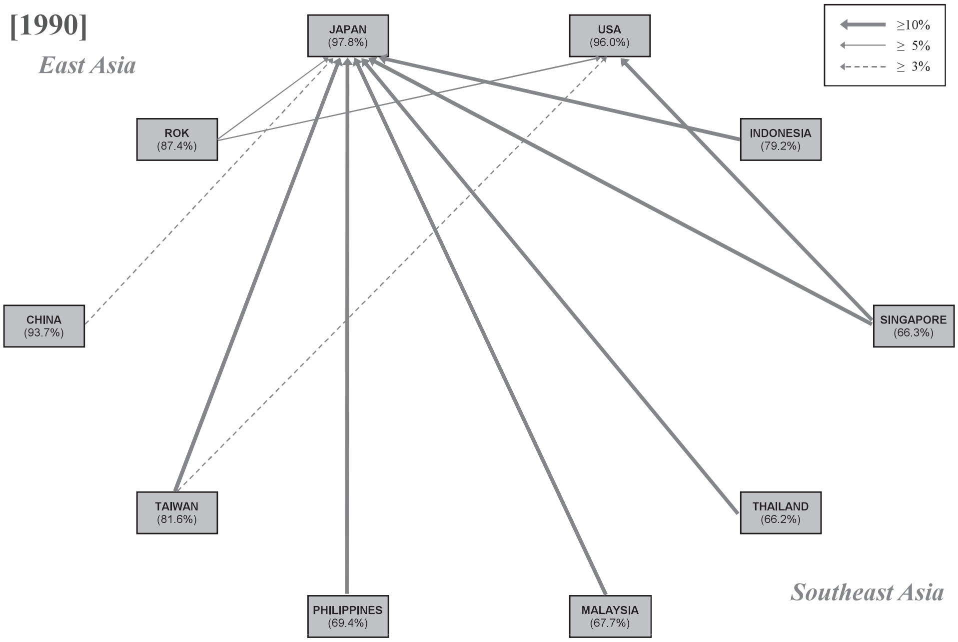
Figure 4 Linkage Structures of the Electronics Industry

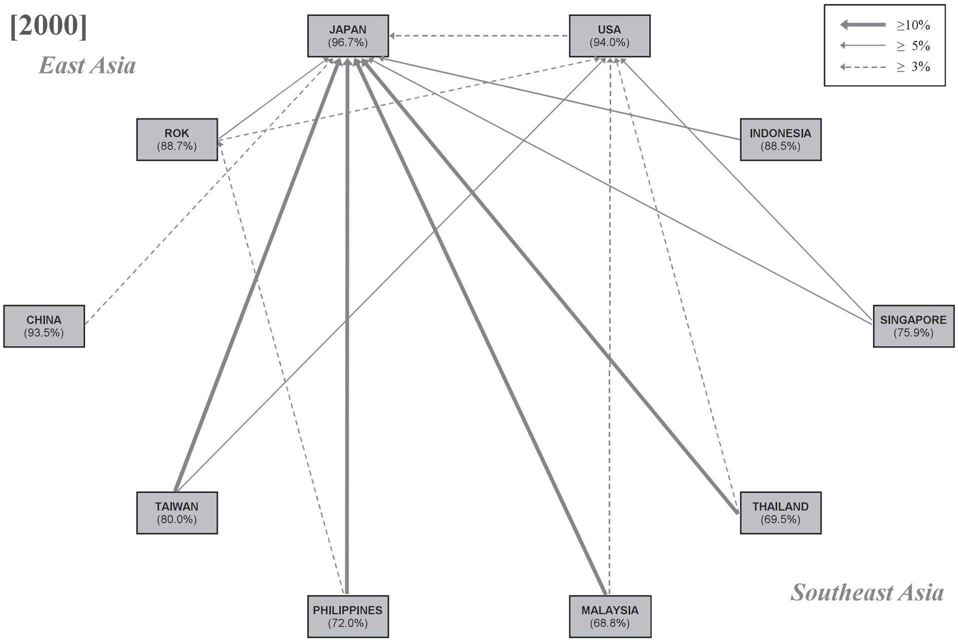




Sources: Calculated from the *Asian International Input–Output Tables* for 1990 and 2000.

Figure 5 Linkage Structures of the Transport Equipment Industry





Sources: Calculated from the *Asian International Input–Output Tables* for 1990 and 2000.

Table 2 Number of Important Cells (All Industries)

1990	China	Indonesia	Japan	ROK	Malaysia	Taiwan	Philippines	Singapore	Thailand	USA	Total	Outgoing	Out./Intra.
China	133		9								**142**	9	6.3%
Indonesia		64	22								**86**	22	25.6%
Japan			78								**78**		0.0%
ROK				76							**76**		0.0%
Malaysia			21	6	77			9	5	16	**134**	57	42.5%
Taiwan			4			65				5	**74**	9	12.2%
Philippines			10				67	2		6	**85**	18	21.2%
Singapore		6	8		6			51	4	12	**87**	36	41.4%
Thailand			5					1	67	5	**78**	11	14.1%
USA										72	**72**		0.0%
Total	**133**	**70**	**157**	**82**	**83**	**65**	**67**	**63**	**76**	**116**	**912**	**162**	**17.8%**
Incoming		6	79	6	6			12	9	44	**162**		
In./Intra.	0.0%	8.6%	50.3%	7.3%	7.2%	0.0%	0.0%	19.0%	11.8%	37.9%	**17.8%**		

2000	China	Indonesia	Japan	ROK	Malaysia	Taiwan	Philippines	Singapore	Thailand	USA	Total	Outgoing	Out./Intra.
China	135										**135**		0.0%
Indonesia	8	63	21	6	1			1		1	**101**	38	37.6%
Japan			81								**81**		0.0%
ROK				77						5	**82**	5	6.1%
Malaysia			13	5	60			7		10	**95**	35	36.8%
Taiwan	4		9			64				9	**86**	22	25.6%
Philippines			8		2	2	54	1		6	**73**	19	26.0%
Singapore					9			54		8	**71**	17	23.9%
Thailand					2			1	61	3	**67**	6	9.0%
USA										63	**63**		0.0%
Total	**147**	**63**	**132**	**88**	**74**	**66**	**54**	**64**	**61**	**105**	**854**	**142**	**16.6%**
Incoming	12		51	11	14	2		10		42	**142**		
In./Intra.	8.2%	0.0%	38.6%	12.5%	18.9%	3.0%	0.0%	15.6%	0.0%	40.0%	**16.6%**		

Source: Author's calculation from the *Asian International Input–Output Tables* for 1990 and 2000.

Table 3 Number of Important Cells (Manufacturing)

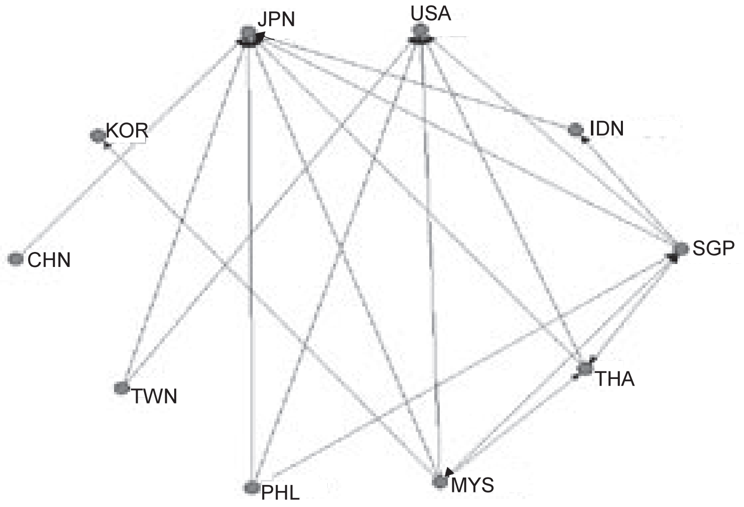
1990	Manufacturing	Agr. & Services
Manufacturing	53	31
Agr. & Services	44	34

2000	Manufacturing	Agr. & Services
Manufacturing	73	22
Agr. & Services	33	14

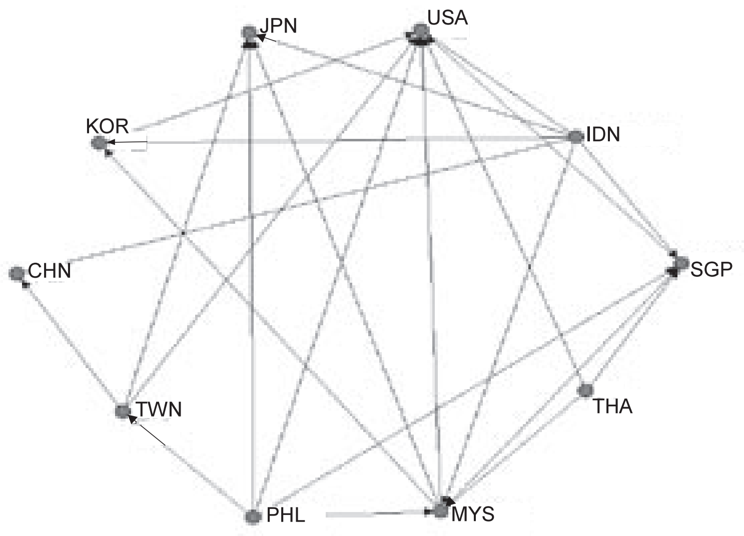
Source: Author’s calculation from the *Asian International Input–Output Tables* for 1990 and 2000.

Figure 6 Networks among Countries

1990

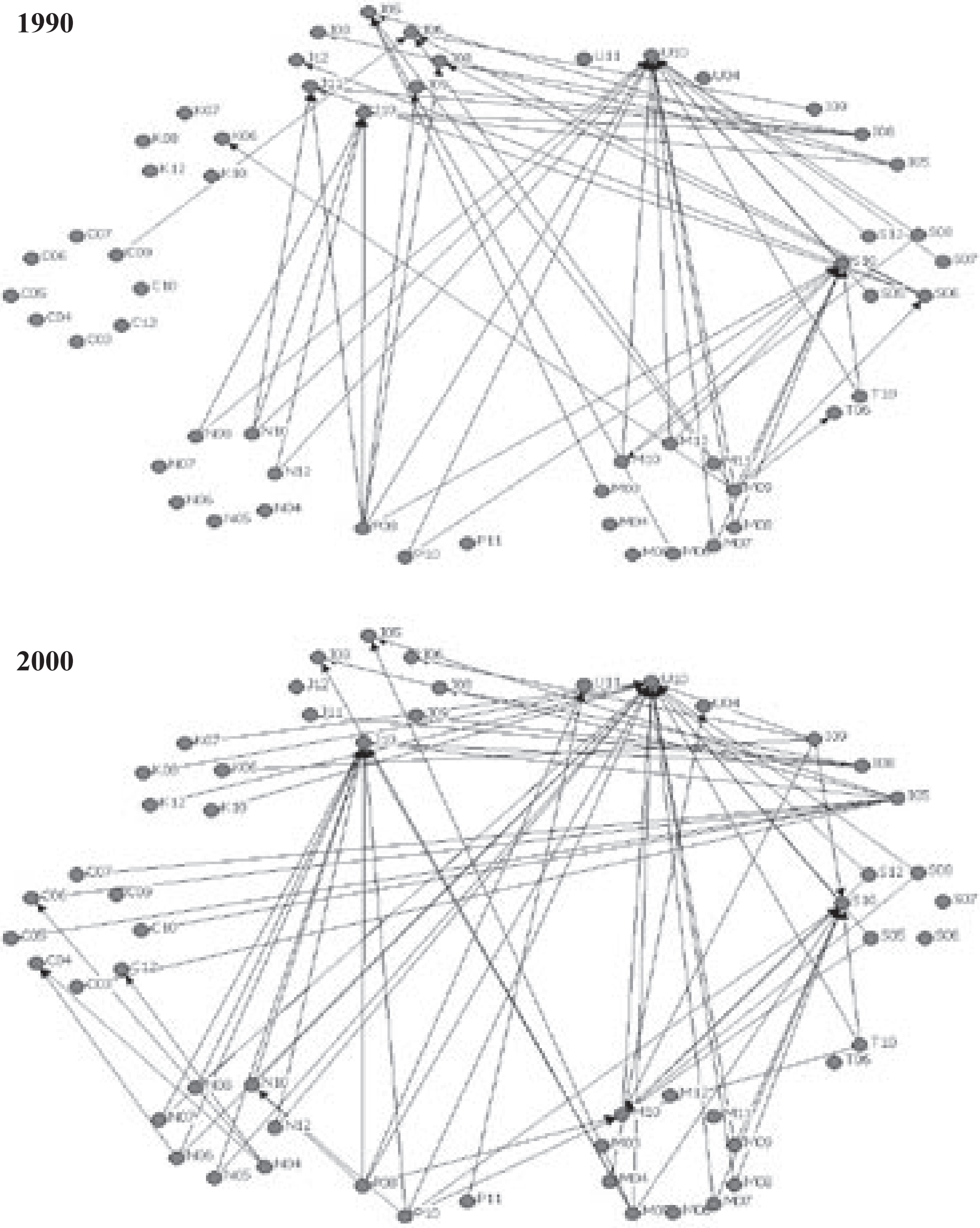


2000



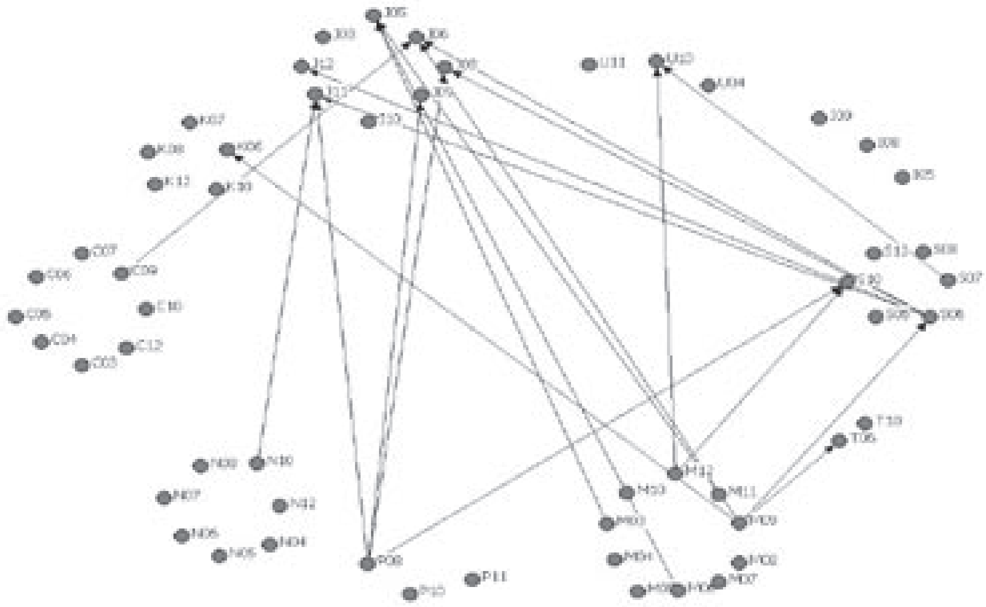
Source: Drawn by the author.

Figure 7 The Networks of the Manufacturing Sectors



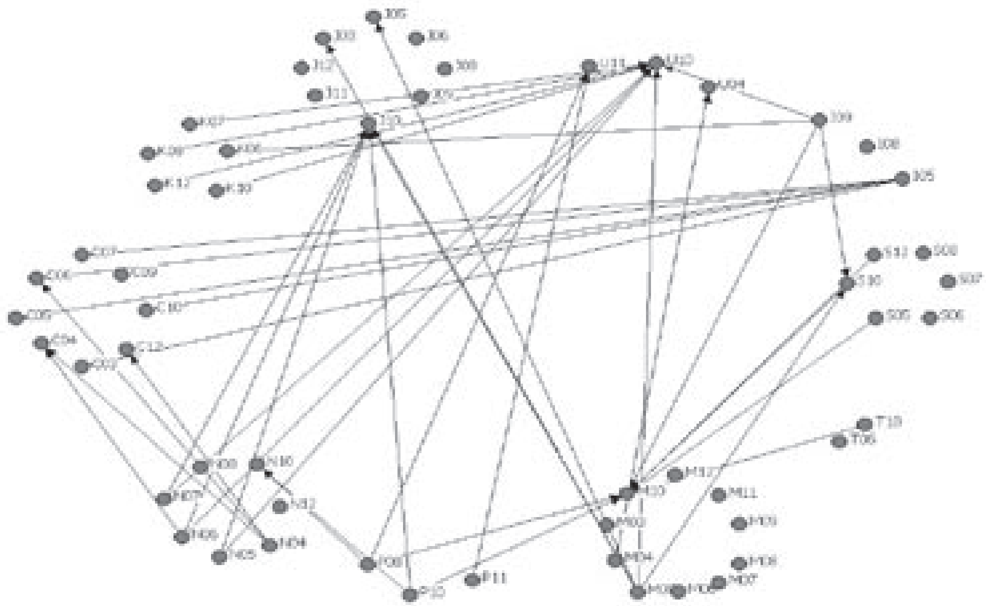
Source: Drawn by the author.

Figure 8 Networks which have Disappeared



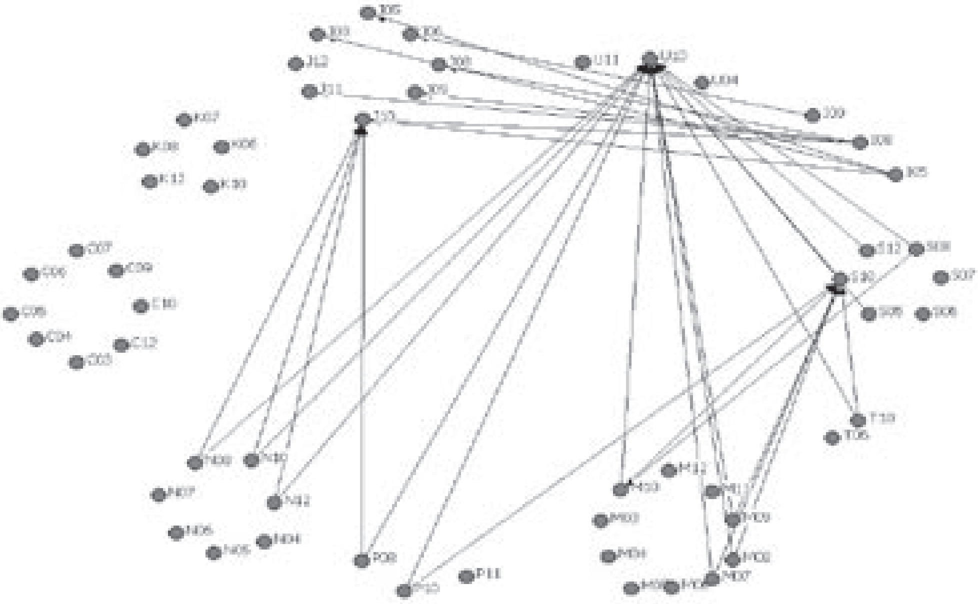
Source: Drawn by the author.

Figure 9 Newly Created Networks



Source: Drawn by the author.

Figure 10 Stable Networks



Source: Drawn by the author.

Appendix 1 Sector Classifications

Code	Description
001	Agriculture, forestry and fisheries
002	Mining and quarrying
003	Food, beverages and tobacco
004	Textiles
005	Other light manufacturing
006	Chemicals
007	Non-metallic mineral products
008	Metal products
009	Machinery
010	Electronics
011	Transport equipment
012	Other manufacturing
013	Electricity, gas and water
014	Construction
015	Trade and transport
016	Services

Appendix 2 Backward Linkage Effects (in Percentage Share)

[1990]

	China	Indonesia	Japan	ROK	Malaysia	Taiwan	Philippines	Singapore	Thailand	USA
[All Industries]										
China	96.637%	0.633%	0.452%	0.047%	1.016%	0.074%	0.495%	2.349%	1.299%	0.137%
Indonesia	0.170%	90.400%	0.430%	0.609%	0.398%	0.475%	0.360%	1.004%	0.224%	0.051%
Japan	1.366%	4.560%	96.818%	4.644%	7.825%	5.962%	7.030%	11.740%	7.555%	0.982%
ROK	0.150%	0.847%	0.290%	89.209%	0.792%	0.548%	1.397%	1.055%	0.898%	0.190%
Malaysia	0.182%	0.304%	0.195%	0.523%	83.130%	0.424%	0.658%	3.424%	1.085%	0.064%
Taiwan	0.379%	0.867%	0.206%	0.404%	1.515%	87.371%	1.806%	1.834%	1.092%	0.239%
Philippines	0.016%	0.044%	0.049%	0.054%	0.073%	0.087%	83.355%	0.136%	0.075%	0.027%
Singapore	0.105%	0.610%	0.076%	0.150%	2.531%	0.397%	0.927%	71.921%	1.259%	0.078%
Thailand	0.057%	0.010%	0.081%	0.097%	0.337%	0.132%	0.130%	0.616%	83.939%	0.039%
USA	0.938%	1.636%	1.403%	4.264%	2.384%	4.529%	3.841%	5.921%	2.573%	98.193%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
[Textile Industry]										
China	96.320%	1.498%	0.440%	0.074%	2.814%	0.082%	1.046%	3.631%	2.058%	0.379%
Indonesia	0.068%	85.277%	0.216%	0.390%	1.117%	0.415%	0.628%	2.731%	0.330%	0.138%
Japan	1.075%	3.175%	95.529%	4.919%	6.943%	4.497%	5.012%	10.028%	4.308%	0.761%
ROK	0.294%	1.899%	0.282%	88.216%	1.972%	1.016%	2.852%	1.202%	1.802%	0.653%
Malaysia	0.104%	0.436%	0.118%	0.331%	73.668%	0.208%	0.467%	3.123%	0.457%	0.091%
Taiwan	0.819%	2.730%	0.322%	1.309%	7.896%	90.048%	9.075%	9.537%	2.662%	0.569%
Philippines	0.007%	0.028%	0.087%	0.033%	0.059%	0.032%	72.048%	0.052%	0.022%	0.072%
Singapore	0.060%	0.685%	0.058%	0.088%	2.273%	0.223%	0.646%	65.379%	0.787%	0.067%
Thailand	0.056%	0.259%	0.191%	0.098%	0.843%	0.127%	0.359%	1.175%	84.447%	0.116%
USA	1.195%	4.013%	2.757%	4.544%	2.415%	3.352%	7.866%	3.144%	3.128%	97.154%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
[Electronics Industry]										
China	94.632%	0.620%	0.266%	0.072%	0.744%	0.098%	0.213%	0.767%	0.723%	0.178%
Indonesia	0.102%	81.329%	0.193%	0.218%	0.349%	0.216%	0.143%	0.431%	0.242%	0.034%
Japan	3.193%	8.475%	96.648%	14.224%	13.151%	16.372%	18.508%	21.077%	17.904%	3.290%
ROK	0.403%	1.461%	0.421%	77.880%	1.392%	1.184%	1.844%	2.230%	1.646%	0.536%
Malaysia	0.133%	0.416%	0.137%	0.489%	69.030%	0.781%	0.654%	3.786%	1.237%	0.271%
Taiwan	0.549%	2.236%	0.443%	0.873%	2.247%	72.477%	2.161%	2.723%	2.562%	0.760%
Philippines	0.016%	0.082%	0.053%	0.107%	0.270%	0.240%	63.449%	0.517%	0.193%	0.077%
Singapore	0.103%	1.855%	0.115%	0.446%	5.719%	1.000%	3.306%	56.821%	5.491%	0.525%
Thailand	0.036%	0.259%	0.084%	0.114%	0.460%	0.215%	0.237%	1.214%	57.842%	0.108%
USA	0.833%	3.267%	1.640%	5.577%	6.639%	7.416%	9.486%	10.435%	12.160%	94.221%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
[Transport Equipment]										
China	93.741%	0.419%	0.203%	0.044%	0.385%	0.062%	0.158%	1.285%	1.402%	0.157%
Indonesia	0.086%	79.166%	0.174%	0.218%	0.272%	0.223%	0.124%	0.656%	0.221%	0.034%
Japan	3.749%	16.884%	97.802%	8.024%	27.604%	12.614%	24.999%	16.942%	26.146%	2.898%
ROK	0.185%	0.616%	0.203%	87.430%	0.367%	0.626%	2.046%	1.057%	0.827%	0.285%
Malaysia	0.115%	0.214%	0.078%	0.213%	67.666%	0.203%	0.317%	1.544%	0.648%	0.091%
Taiwan	0.348%	0.509%	0.165%	0.351%	0.655%	81.611%	0.838%	1.160%	0.967%	0.388%
Philippines	0.016%	0.035%	0.041%	0.044%	0.026%	0.069%	69.370%	0.095%	0.098%	0.028%
Singapore	0.095%	0.479%	0.046%	0.136%	0.935%	0.306%	0.367%	66.256%	0.890%	0.099%
Thailand	0.049%	0.092%	0.042%	0.046%	0.155%	0.055%	0.179%	0.354%	66.198%	0.040%
USA	1.616%	1.585%	1.246%	3.494%	1.934%	4.230%	1.602%	10.653%	2.604%	95.981%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%

Source: Calculated from the *Asian International Input–Output Table 1990*.

[2000]

	China	Indonesia	Japan	ROK	Malaysia	Taiwan	Philippines	Singapore	Thailand	USA
[All Industries]										
China	94.022%	1.295%	0.742%	1.817%	1.893%	1.576%	1.678%	2.413%	1.812%	0.551%
Indonesia	0.239%	90.151%	0.385%	0.701%	1.052%	0.746%	1.263%	0.884%	0.644%	0.091%
Japan	1.957%	3.320%	96.464%	3.402%	7.747%	5.925%	5.744%	7.019%	6.970%	1.119%
ROK	1.180%	1.099%	0.399%	89.883%	1.583%	1.324%	2.419%	1.213%	1.027%	0.356%
Malaysia	0.212%	0.678%	0.250%	0.413%	77.222%	0.662%	1.463%	3.744%	1.048%	0.163%
Taiwan	1.043%	0.652%	0.269%	0.407%	1.874%	84.861%	1.910%	1.030%	1.099%	0.362%
Philippines	0.046%	0.039%	0.062%	0.082%	0.243%	0.194%	79.796%	0.154%	0.178%	0.081%
Singapore	0.184%	0.489%	0.073%	0.242%	3.245%	0.533%	1.491%	77.562%	0.907%	0.126%
Thailand	0.139%	0.385%	0.135%	0.164%	1.157%	0.370%	0.774%	1.106%	83.718%	0.118%
USA	0.978%	1.891%	1.221%	2.890%	3.984%	3.808%	3.462%	4.875%	2.598%	97.035%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
[Textile Industry]										
China	93.804%	2.347%	2.017%	5.008%	4.594%	1.286%	4.336%	5.257%	3.448%	1.196%
Indonesia	0.208%	85.956%	0.594%	1.056%	2.728%	1.111%	1.639%	0.582%	0.699%	0.445%
Japan	2.066%	2.592%	94.397%	2.579%	7.102%	4.703%	3.992%	3.666%	2.826%	0.879%
ROK	1.475%	2.309%	0.602%	87.259%	2.075%	1.707%	4.852%	2.276%	1.650%	0.753%
Malaysia	0.128%	0.742%	0.204%	0.300%	68.976%	0.592%	0.591%	4.754%	0.562%	0.274%
Taiwan	1.501%	1.683%	0.500%	0.995%	5.747%	86.153%	9.076%	1.890%	2.330%	1.025%
Philippines	0.020%	0.036%	0.033%	0.030%	0.173%	0.111%	68.659%	0.220%	0.085%	0.125%
Singapore	0.087%	0.427%	0.042%	0.120%	3.329%	0.333%	0.621%	76.495%	1.027%	0.100%
Thailand	0.113%	0.584%	0.289%	0.401%	1.582%	0.589%	1.812%	1.606%	85.763%	0.475%
USA	0.598%	3.325%	1.323%	2.252%	3.695%	3.417%	4.421%	3.253%	1.611%	94.729%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
[Electronics Industry]										
China	88.232%	1.683%	0.952%	2.272%	3.045%	2.354%	1.528%	3.665%	5.076%	1.130%
Indonesia	0.201%	86.701%	0.241%	0.307%	0.926%	0.526%	0.437%	0.858%	0.931%	0.106%
Japan	3.554%	4.450%	93.251%	9.710%	13.642%	13.678%	18.248%	14.464%	14.540%	3.607%
ROK	2.116%	1.562%	0.987%	74.022%	3.245%	3.996%	4.837%	2.501%	3.358%	1.453%
Malaysia	0.625%	0.866%	0.528%	1.400%	53.463%	2.063%	1.840%	5.851%	3.332%	0.810%
Taiwan	2.214%	0.819%	1.191%	2.069%	3.785%	67.037%	2.834%	2.267%	2.686%	1.328%
Philippines	0.209%	0.064%	0.260%	0.570%	1.293%	1.126%	53.727%	0.319%	0.707%	0.410%
Singapore	0.572%	1.022%	0.329%	1.228%	7.449%	1.961%	3.585%	60.860%	3.586%	0.855%
Thailand	0.318%	0.545%	0.218%	0.466%	2.332%	0.859%	1.337%	1.351%	57.665%	0.328%
USA	1.959%	2.289%	2.044%	7.955%	10.821%	6.399%	11.629%	7.864%	8.119%	89.972%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%
[Transport Equipment]										
China	93.542%	1.781%	0.565%	1.475%	1.819%	1.731%	2.380%	2.135%	1.674%	0.873%
Indonesia	0.121%	88.541%	0.181%	0.355%	0.788%	0.358%	2.061%	1.166%	0.525%	0.076%
Japan	2.960%	6.204%	96.672%	5.249%	18.391%	10.054%	11.456%	8.897%	20.635%	3.250%
ROK	1.040%	0.623%	0.311%	88.702%	1.678%	1.423%	3.483%	1.262%	1.209%	0.560%
Malaysia	0.147%	0.394%	0.147%	0.263%	68.845%	0.473%	1.574%	2.184%	0.884%	0.224%
Taiwan	0.956%	0.447%	0.263%	0.353%	1.713%	80.041%	2.165%	0.754%	1.084%	0.533%
Philippines	0.033%	0.057%	0.070%	0.061%	0.150%	0.130%	72.018%	0.107%	0.636%	0.146%
Singapore	0.147%	0.311%	0.057%	0.220%	2.133%	0.352%	1.247%	75.937%	0.646%	0.168%
Thailand	0.109%	0.379%	0.271%	0.118%	0.959%	0.218%	0.971%	0.660%	69.532%	0.142%
USA	0.945%	1.263%	1.464%	3.203%	3.524%	5.221%	2.645%	6.899%	3.176%	94.028%
Total	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%	100.000%

Source: Calculated from the *Asian International Input–Output Table 2000*.

Some Simulation Experiments with an Annual Econometric Model of Japan*: In the Context of a Link Model for East Asian Economies

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Abstract

This paper presents an annual macro-econometric model of the Japanese economy, designed for incorporation within a small link-model for East Asian economies. The model also attempts to capture the boom and bust of assets prices, describing the supply side of the macro-economy in addition to the usual Keynesian-type macro-model. We tried some simulation experiments, and found the results were within reasonable ranges. For example, the real public investment multipliers were 1.845 without taxation and 0.660 with full taxation, both in the long term. The real GDP increased 1.3 percent, in the long term, via the raising of nominal public investment by one percent of the amount of nominal GDP.

Keywords: *Japanese economy, macro-econometric model, Keynesian-type model, multiplier analysis, East Asian link model*

1. Introduction

This paper presents an annual macro-econometric model of the Japanese economy. The model is designed for incorporation within a small link-model for East Asian economies. In line with this purpose, the model was particularized to capture the external linkages with partner economies through international trade and direct investment. It also attempts to describe the boom and bust of asset prices, and the supply side of the macro-economy, using a Cobb-Douglas production function.

2. Overview of the Modeling

The Japanese economy in the 1990s has shown a contrasting performance in growth compared to that recorded in the 1980s. Real GDP growth in the 1990s has averaged 1 percent annually, as opposed to the 4 percent recorded in the 1980s. One of the major factors responsible for this contrast is the bubble period and the collapse of asset prices. After the middle of the 1980s, a self-reinforcing cycle of rising stock and land prices contributed to strong economic growth. Stock prices peaked in December 1989, and land prices a year later. Once asset prices began to fall, the process operated in reverse. In the 1990s, there was first a fall in private fixed investment, then residential investment, followed by inventories, and finally private final consumption. As a result the demand side depressed the Japanese economy sharply, which was in a decade-long slump.

The model is intended to describe quantitatively these contrasting macro-economic

* Econometric modeling in this paper was originally done for the ICSEAD research project of 2000–-2001, titled "Econometric Studies on the Growth Patterns and International Economic Links in the East Asian Economies". As the national account data used here was were based on 68SNA, re-estimation of the model using a new system, 93SNA remains to be a an urgent task for us.

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performances for the two decades from 1980 to 2000, using a medium-sized econometric model.

3. Structure of the Model

In this section, we explain the block structure of the model and the features of each block, focusing on the main behavioral equations included therein.

3.1 Block structure of the model

The model consists of seven blocks. They are: the aggregate demand block; the production and employment block; the price and wage block; the income block; the government fiscal block; the monetary block; and the balance of payment and exchange rate block. Variables in each block are related interdependently to one another as shown in Figure 3.1.

3.2 Overview of each block

The model consists of 77 equations as a whole: 49 equations are statistically estimated; the rest are identities. In the following we outline the major behavioral equations which were specified based on the Keynesian demand-determined model.

3.2.1 Aggregate demand block

This block consists of the demand components of aggregate demand. Equations (1)–(10) determine endogenously the following six variables in real terms; private final consumption, private residential investment, private business fixed investment, inventory investment, exports, and imports. Private final consumption depends positively on real personal disposable income and household net-wealth, and negatively on price inflation. Private business fixed investment is related to production, the real cost of capital, and the net assets of foreign direct investment outward. Nominal government final consumption and investment are treated as exogenous and the real values are given by definition. Equations (11)–(18) determine the nominal values of the remaining demand components as a product of each real value and deflator. Equations (19)–(21) link investments individually with capital stock for private residential capital, private business fixed capital and inventory stock.

(1) GDP = CP+CG+IHP+IFP+IG+J+BF

(2) CP = $\alpha + \beta$ (YDV/PCP)+ γ NWHV(-1)/PCP+ δ (RGB-gr(PCP))

(3) CG = CGV/PCG∗100

(4) IHP = $\alpha + \beta$ (YDV/PCP)+ γ (RGB-gr(PIHP))+ δ KHP(-1)

(5) IFP/KFP(-1) = $\alpha + \beta$ {GDP/KFP(-1)}+ γ {PIFP∗(df+RGB)/PGDP/KFP(-1)} + δ {(FASIV-FLBIV)/PIFP/KFP(-1)}

(6) IG = IGV/PIG∗100

(7) J/KJ(-1) = $\alpha + \beta$ CU+ γ (GDP/KJ(-1))+ δ (RCD-gr(PJ))

(8) XGS = $\alpha + \beta$ (WYVI)+ γ (PXGS/FXS/WPX)+ δ (XGS(-1))

(9) $MGS = \alpha + \beta (GDP) + \gamma (PMGS/PGDP) + \delta MGS(-1)$
(10) BF = XGS-MGS
(11) GDPV = CPV+CGV+IHPV+IFPV+IGV+JV+BFV
(12) CPV = CP•PCP/100
(13) IHPV = IHP•PIHP/100
(14) IFPV = IFP•PIFP/100
(15) JV = (KJ•PJ-KJ(-1)•PJ(-1))/100+JVA
(16) XGSV = XGS•PXGS/100
(17) MGSV = MGS•PMGS/100
(18) BFV = XGSV-MGSV
(19) KHP = IHP+(1-dh)KHP(-1)
(20) KFP = IFP+(1-df)KFP(-1)
(21) KJ = J+KJ(-1)
where, gr(x) in the equation stands for the percentage change of x.

3.2.2 Production and employment block

In this model, the unemployment rate is determined not by identity but by a function of production, the real wage (per capita labor income) and the rate of capacity operation in the manufacturing sector, as shown in Equation (22). Total employment is then derived, by definition, from the unemployment rate and labor force. The number of employees is related statistically to total employment.

The rate of capacity operation is explained in Equation (26) by the ratio of realized GDP to potential GDP and the employment rate. Potential GDP is computed from the estimated Cobb-Douglas production function given full utilization of labor and capital stock in Equation (25). Hours worked is related endogenously to operation rate and time in Equation (27).

(22) $UR = \alpha + \beta (GDP/LF) + \gamma (W/PGDP) + \delta CU$
(23) LE = LF(1-UR)
(24) $LW = \alpha + \beta (LE)$
(25) $\ln(GDPP) = \alpha + \beta \ln(LF \cdot LHop) + \gamma \ln(KFP(-1) \cdot CUop) + \delta TIME$
(26) $CU = \alpha + \beta (GDP/GDPP) + \gamma (LE/LF)$
(27) $LH = \alpha + \beta LE + \gamma CU + \delta TIME$

3.2.3 Price and wage block

This block covers the determination of the wage rate and several price indices and deflators. In Equation (28) the wage rate (per capita labor income) is determined from labor productivity and consumer price. The domestic wholesale price index, a core variable of this block, is affected by the import price, unit labor cost and rate of capacity operation in Equation (29). Equations (31)–(38) are specified to explain each demand deflator by the domestic wholesale price index, and wage rate if necessary. The export deflator is assumed to be affected by the yen exchange rate as an additional explanatory variable. The import deflator is defined as a product of the import price in dollar terms and the yen exchange rate. The GDP deflator in Equation (30) is determined as a ratio of nominal GDP to real GDP.

(28) $W = \alpha + \beta (GDP/LW) + \gamma PCP$
(29) $DPI = \alpha + \beta PMGS + \gamma CU + \delta (W \cdot LW/GDP)$
(30) $PGDP = GDPV/GDP$
(31) $PCP = \alpha + \beta DPI + \gamma W$
(32) $PCG = \alpha + \beta DPI + \gamma W$
(33) $PIHP = \alpha + \beta DPI + \gamma W$
(34) $PIFP = \alpha + \beta DPI$
(35) $PIG = \alpha + \beta DPI + \gamma W$
(36) $PJ = \alpha + \beta DPI$
(37) $PXGS = \alpha + \beta DPI + \gamma FXS$
(38) $PMGS = PMGSD * FXS/144.81$

3.2.4 Income block

In the income distribution block several income variables are determined either by identity or behaviorally. National income at factor cost, personal disposable income, and total income of employees are determined as identities. The income of self-employed persons in Equation (42) is related to per capita employee income and the number of self-employed persons. Personal property income is a function of government bond yield and household net wealth. Corporate income is explained by nominal GDP minus the compensation of employees, income of private unincorporated enterprises, and property income, and the long-term interest rate in, Equation (44). Change in household net wealth is related positively to personal saving and to the stock price index as a revaluation adjustment factor.

(39) $NIV = YWV + YICV + YCV + YIV$
(40) $YDV = YWV + YICV + YIEV + BSSV - CSSV - TYPV + OYDV$
(41) $YWV = W * LW$
(42) $YICV = \alpha + \beta \{W \cdot (LE - LW)\}$
(43) $YIEV = \alpha + \beta (RGB \cdot NWHV(-1))$
(44) $YCV = \alpha + \beta (GDPV - YWV - YICV - YIV) + \gamma RGB$
(45) $YIV = \alpha + \beta (YIEV + YIGV)$
(46) $JVA = \alpha + \beta \{(PJ - PJ(-1)) \cdot KJ(-1)\}$
(47) $NWHV - NWHV(-1) = \alpha + \beta (YDV - CPV) + \gamma\, gr(PSHARE)$

3.2.5 Government fiscal block

This block is contained within the fiscal balance of general government. The revenue side covers tax revenue, social security contributions and the income from government property, while the spending side here is specified only in order to explain social security benefits. The remaining government spending items are treated as exogenous. In equations (48)–(50) direct tax (personal income and corporate income) and indirect tax are related to their respective taxable incomes and expenditures. Equations (53)–(54) are concerned with revenue and the spending of social security. The social security benefits in Equation (54) depend mainly on the wage rate, size of the population over 65 years old, and number of unemployed persons. Equation (56) determines the cumulative fiscal balance, which may affect the long-term interest rate in the financial block.

(48) TYPV = $\alpha + \beta$ (YWV+YICV+YIEV)+ γ UR
(49) TYCV = $\alpha + \beta$ (YCV+JVA)+ γ CU
(50) TAXIV = $\alpha + \beta$ (CPV+CGV+IHPV)+ γ (IFPV+MGSV)
(51) TAXV = TYPV+TYCV+TAXIV
(52) YIGV = $\alpha + \beta$ (RGB・SBGV(-1))
(53) CSSV = $\alpha + \beta$ (YWV+YICV)
(54) BSSV = $\alpha + \beta$ (W・POP65)+ γ (W・UR・LF)+ δ YDV
(55) BGV = TAXV+CSSV+YIGV+OTGV-{CGV+IGV+BSSV+SUBV}
(56) SBGV = SBGV(-1)+BGV

3.2.6 Monetary block

The monetary block explains six monetary and related financial variables. Money supply in Equation (57) is based on liquidity preference, and specified as a function of GDP and the yield of certificates of deposit, and household net wealth is also taken into account. In equations (58)–(59), the short-term interest rate is related to the official discount rate and changes in consumer prices, while the long-term rate is assumed to be affected by the term structure of interest rates and the fiscal balance per nominal GDP. The stock price is a function of corporate profitability, the land value index and the inflation factor. The land value index in Equation (62) is related to nominal GDP, the long-term interest rate adjusted for inflation, and the wealth factor.

(57) M2CD = $\alpha + \beta$ GDPV+ γ NWHV(-1)+ δ RCD
(58) RCD = $\alpha + \beta$ RDIS+ γ gr(PCP)
(59) RGB = $\alpha + \beta$ RCD+ γ gr(PCP)+ δ (SBGV/GDPV)
(60) PSHARE = $\alpha + \beta$ PLAND+ γ (YCV/(KFP(-1)・PIFP))+ δ RGB
(61) PER = $\alpha + \beta$ (PSHARE/GDPV)
(62) PLAND = $\alpha + \beta$ gr(GDPV)+ γ (RGB-gr(PGDP))+ δ (NWHV(-1)/GDPV)

3.2.7 Balance of payment and exchange rate block

Current balance (65) is the sum of the trade balance and net transfer payments. Transfer payments to and from the rest of the world are basically determined in equations (63)–(64) by the respective financial assets multiplied by the yield on government bonds.

Capital accounts are divided into financial assets (or liabilities), direct investment, and other assets (or liabilities). External assets and liabilities (assets of the rest of the world) are affected by interest differentials between domestic and foreign markets, direct investment outward and inward, and total assets[1]. Conventionally foreign reserves are determined reflecting the difference between external assets and liabilities. In this model, however, an alternative specification is adopted as follows:

First, the cumulative current balances are related statistically to foreign reserves in Equation (75). Then the cumulative capital account balances are determined as the sum of the cumulative current balances and foreign reserves. Further external asset totals are derived in Equation (67) as the sum of the cumulative capital balances and external liability totals. External asset totals are divided into each component in Equations (68)–(79).

[1] In our model, assets and liabilities for capital accounts (67)–(74) are evaluated as those of Japan, which is opposite to the conventional form of themethod where international transactions to are be described from the point of view of the rest of the world.

The yen exchange-rate is assumed to depend on the differentials of the inflation and interest rates between the domestic and US markets, and the cumulative trade surplus ratio.

(63) RTRIV = $\alpha + \beta$ (USRGB*FASV(-1)/100)
(64) PTRIV = $\alpha + \beta$ (RGB*FLBV(-1)/100)+ γ ODA
(65) BCV = BFV+(RTRIV-PTRIV)+ERRBCV
(66) SBCV = SBCV(-1)+BCV
(67) FASV = FLBV-SBCPV
(68) FASMV = $\alpha + \beta$ (FRGB-RGB)+ γ FASV+ δ FASMV(-1)
(69) FASIV = $\alpha + \beta$ (FGDPV/GDPV)+ γ FXS+ δ FASV+ ε FASIV(-1)
(70) FASOV = FASV-(FASMV+FASIV)
(71) FLBV = FLBMV+FLBIV+FLBOV
(72) FLBMV = $\alpha + \beta$ (FRGB-RGB)+ γ FXS+ δ FLBMV(-1)
(73) FLBIV = $\alpha + \beta$ (FGDPV/GDPV)+ γ FXS+ δ FLBIV(-1)
(74) FLBOV = $\alpha + \beta$ FLBV+ γ FLBOV(-1)
(75) SBCPV = FCR-(SBCV+FSD)
(76) FCR = $\alpha + \beta$ SBCV
(77) FXS = $\alpha + \beta$ (DPI/USPPI)+ γ (USRGB-RGB)+ δ (SBCV/GDPV)

4. Estimated Results

The model uses annual data from 1980 to 1997. Data were mostly obtained, with the exception of capital stock and its related data, from the Annual Report of National Accounts of the Economic and Social Research Institute of the Cabinet Office. Data in real terms are in 1990 prices. Ordinary least squares were used for the estimation. The estimation results are given in Appendix A, along with a list of the variables in Appendix B.

5. Simulation Tests

Some simulation tests were done for the sample period from 1981 to 1997. Looking at the MAPE (Mean Absolute Percentage Error) values in Table 5.1, we find that those of the main endogenous variables are within 3–5 percent, although some variables, i.e. business investment and imports, have relatively high MAPE values in Table 5.2. We will therefore have to improve our model in this area. Here the error rates of stock valuation adjustment and changes in inventories, nominal and real, exceed 100 percent. Those of the expenditure of general government, the balance in international trade accounts, the stock index, and the property income of general government are within 10–100 percent. In general, the variance in such variables as changes in inventories and the balances in international trade are large, and the values of those variables sometimes approach zero, consequently making error rates large.

Figure 5.1 shows a comparison of the actual and computed values in the final test. Almost all variables perform well in that the computed values follow the trends of the actual variables, although there are some variables which are exceptions—like business fixed investment, imports, the unemployment rate, the exchange rate, and stock variables in international trade—whose estimation we will have to improve.

Secondly, we conducted the initial value test in a dynamic simulation. Here we computed some dynamic simulations, altering the starting year. Figure 5.2 shows the results of GDP simulations for three different periods: (1) 1981–1997; (2) 1986–1997; and (3) 1991–1997. Looking at this figure, we can conclude that our model adequately explains different sample periods with different initial values for predetermined variables.

6. Multiplier Analysis

6.1 Multiplier Tests

Here we tried some multiplier tests with the model in order to capture the structural features of the Japanese economy. Firstly, we evaluated the effect of nominal public investment, raising it by 1 trillion yen. Figure 6.1 shows the effect on GDP from the change in public investment, in the two rates of change in GDP, nominal and real, respectively. These values were computed from the simulations of the initial value tests for three different periods, to compare the differences in multiplier values among the three simulations.

Looking at the simulation starting in 1981, the value of the real multiplier was 1.415 in the first year, rose to 1.609 in the third year, and declined gradually to 1.367 in the seventh year. After that, it increased again and reached 1.845 in the final year. The value of the nominal multiplier was 1.454 in the first year, and increased with small reversals to 2.628 in the final year.

On the other hand, for the simulation starting in 1986, the real multiplier of the first year was 1.714, and declined gradually to its lowest point, 1.341, in the tenth year. Thereafter it increased steadily to reach 1.555 in the final year. The nominal multiplier was 1.876 in the first year, and climbed until the sixth year, then after a decline increased to 2.197 in the final year.

For the simulation starting in 1991, the real multiplier was 1.933 at the beginning, and declined to 1.328 in the sixth year, increasing in the year after that. The nominal multiplier was 2.064 in the first year, 2.089 in the second, 1.763 in the sixth, and 1.839 in the final year.

The values of the real multipliers in each case ranged from approximately 1.4 to 1.9 in the first year, and those of the nominal multipliers from approximately 1.4 to 2.1. The real multipliers appear to be more stable than the nominal multipliers. The stock variables of government budget, international accounts, and household assets seem strongly to affect price variables and household incomes through interest rates and the exchange rate in our model.

We tried adding some assumptions concerning the financing of the one-trillion-yen increase of nominal public investment. The following three cases were conducted:

B-1: Increasing public investment by 1 trillion yen.
B-2: Increasing public investment by 1 trillion yen, and tax revenues by half that amount.
B-3: Increasing public investment by 1 trillion yen, and tax revenues by the same amount.

Here, regarding the cases where tax revenues were increased, we changed household income tax, corporate business tax, and indirect taxation by using actual shares of 0.35, 0.25, and 0.40, respectively. In the cases where the increase in expenditure was not financed in part or entirely by taxation, we assumed that government bonds were issued for the deficit in the general government budget in our model.

Figure 6.2 shows that the more financing by tax revenues, the lower both nominal and real multipliers. In the cases where government expenditure was financed in its entirety by tax revenues, the real multiplier approached a value of 1. This is an instance of the so-called "balanced-budget multiplier."

Nominal values of the long-term multiplier were 2.628, 1.723 and 0.845 for B-1, B-2 and B-3, respectively. On the other hand, the real values were 1.845, 1.203 and 0.660 for B-1, B-2 and B-3, respectively. The greater the financing by tax revenues, the lower the government budget deficit. In this case, it is thought that the effect on prices was not so strong, and private consumption and residential investment were caused to decline because of a decrease in income.

Considering the results of these multiplier tests, there might be some room to improve our model in its long-term dynamic properties. We subsequently tried some simulations using multiplier analysis for the sample period of 1991 to 1997, because we consider it better to use the latest sample period as the basis for simulations.

6.2 Some Simulation Analyses

Here we conducted the following five scenarios as multiplier analyses:

(1) Increasing nominal public investment, IGV, by 1 percent of the amount of nominal GDP.
(2) Increasing the official discount rate, RDIS, by 1 percentage point.
(3) Increasing average domestic prices of developed countries, WPX, by 10 percent.
(4) Increasing the real GDP of export market countries, WYVI, by 10 percent.
(5) Increasing the US bond yield, USRGB, by 1 percentage point.

In scenarios (3) and (4), we were able to examine the impact of the change in real exports in our model. In scenario (5), factor income from abroad, financial assets moving abroad, financial debt moving abroad, and exchange rates are important channels affecting endogenous variables.

(1) Increasing nominal public investment, IGV, by 1 percent of the amount of nominal GDP.

Increasing government expenditure induced an expansion in GDP and disposable income that in turn induced an increase in final consumption, residential investment, business fixed investment, and import demand, etc. GDP increased by 1.909 percent in the first year, and by 1.322 percent in the seventh year. These effects might have been slightly larger than the values in the other studies of recent macro-econometric models for Japan making short-term forecasts. For example, in the study of the macro-econometric model of the Economic Planning Agency, Japan (1998), a sustained change in nominal public investment by 1 percent of the amount of nominal GDP induced an increase in real GDP, whose multiplier values were 1.22 in the first year, 1.29 in the second year, and 1.16 in the third year. The nominal multiplier values were 1.31 in the first year, 1.65 in the second year, and 1.97 in the third year.

The increase in government expenditure makes the budget balance worse. If bonds are issued to finance the deficit of the balance, the long-term interest rate will be raised. In our model, RGB (the yield rate of bonds) rose by 0.268 of a percentage point in the first year, and by 0.134 of a percentage point in the seventh year. Although the raising of the interest rate resulted in an exchange rate depreciation, increased import demand affected the exchange rate in the opposite direction by changing the international trade balance. In our model, the exchange rate depreciated by 0.796 percent in the first year, and by 3.710 percent in the seventh year, because the effect via international trade was stronger than that via the interest rate.

The depreciated exchange rate increased export demand, which raised real GDP even further. On the other hand, it raised domestic wholesale prices, which induced increases in each deflator and the wage rate. Augmented real GDP induced additional labor demand, and decreased the unemployment rate. In the model the unemployment rate decreased by 0.050 of a percentage point in the first year and by 0.253 of a percentage point in the seventh year.

The decreased accumulated current balance of international transactions, SBCV, reduced the deficit in the accumulated capital balance, SBCPV. On the other hand, the accumulated fiscal balance, SBGV, made the deficit rise. The accumulated current balance is reduced not only by the reduction in the trade balance but also by the increased factor transfer to abroad because of the increase in the domestic interest rate. Regarding the change in accumulated capital balance, the increased financial assets of the foreign sector, via the increased GDP and interest rate, had a strong effect.

(2) Increasing the official discount rate, RDIS, by 1 percentage point.

Increasing the official discount rate directly affected the short-term and long-term interest rates. Business investment decreased through the increase in cost factor. Although the business investment decreased by 1.595 percent in the first year, it recovered from the second year on, and increased by 5.997 percent in the seventh year. This can be explained in the following way. The increased interest rate raised household property income, which induced an augmented demand in consumption and residential investment. These increased the real GDP, which affected investment demand. In our model, this effect on income by the interest rate was clearly exhibited. The increased interest rate stimulated investment from abroad, which improved the capital balance situation in international transactions. Increased GDP stimulated export demand, which worsened the current balance.

(3) Increasing average domestic prices of developed countries, WPX, by 10 percent.

(4) Increasing the real GDP of export market countries, WYVI, by 10 percent.

Both these scenarios directly brought about an increase in export demand. Exports increased by 5.123 percent in the first year, then by 5.770 percent in the second year, and finished at a 3.593 percent increase in the seventh year for scenario (3). For scenario (4) on the other hand, they increased by 9.718 percent in the first year, by 10.967 percent in the second year, then 6.582 percent in the seventh year. This difference was due to the difference between income elasticity and price elasticity in the export demand function.

Export demand increased GDP not only directly as one component of expenditure items, but also with a multiplier effect via augmented consumption and investment. GDP increased by 1.087 percent and 2.062 percent in the first year, and by 0.940 percent and 1.737 percent in the seventh year, for scenarios (3) and (4), respectively. Tax revenues were expected to rise, with the consequence that the government budget balance improved. Therefore the long-term interest rate fell. In the labor market, because employment demand increased, unemployment decreased.

Increased exports improved the current balance situation, and the outward financial and direct investment overseas worsened the capital balance situation. The increase in the current balance caused the exchange rate to appreciate. Although the exchange rate depreciated by 0.721 percent and 1.355 percent in the first year, it appreciated from the second year on, and appreciated by 7.625 percent and 14.222 percent in the seventh year, for scenarios (3) and (4), respectively. The appreciated exchange rate had the effect of depressing domestic prices.

(5) Increasing the US bond yield, USRGB, by 1 percentage point.

Increasing the US interest rate had a direct effect on financial assets and debts, and the exchange rate. The outflow of funds brought by the higher US interest rate worsened the capital balance situation. The accumulated capital balance changed by 3.721 percent in the first year, and 20.949 percent—but in a negative direction—in the seventh year. Although the exchange rate depreciated by 1.477 percent in the first year, and 2.006 percent in the second year, it appreciated from the fourth year on, and ended up appreciating by 6.393 percent in the seventh year. The depreciated exchange rate stimulated export demand and depressed import demand. Our model, however, revealed the much greater effect of a raised US interest rate on the accumulated current balance via the increase of factor income from abroad, which changed the appreciation of the exchange rate.

In this case, GDP decreased by 0.223 percent in the first year, and by 0.453 percent in the seventh year, because private business investment decreased by 1.360 percent in the first year, by 2.999 percent in the fourth year, and by 1.635 percent in the seventh year. The reduction in foreign direct investment largely brought about this depressed investment.

7. Concluding Remarks

Our econometric model of Japan is adequately capable of explaining the sample data for almost all the endogenous variables. There is still room to improve some of the equations in the model, however. The actual results of our model simulation tests show that some variables have relatively large errors. The equations containing these variables need to be respecified.

We evaluated some multiplier simulations. Although the main variables show the changes in the expected direction, the sizes of the effects should be compared more carefully with the other related studies in Japan. In particular, we should examine the relationship between domestic business investment and foreign direct investment, the specification of stock variables in the international transactions block, the relationship between stock variables and flow variables in the model, and the route of the influence from asset prices (stock and land prices) to real variables.

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Figure 3.1 Flow- Chart for Japan's Model

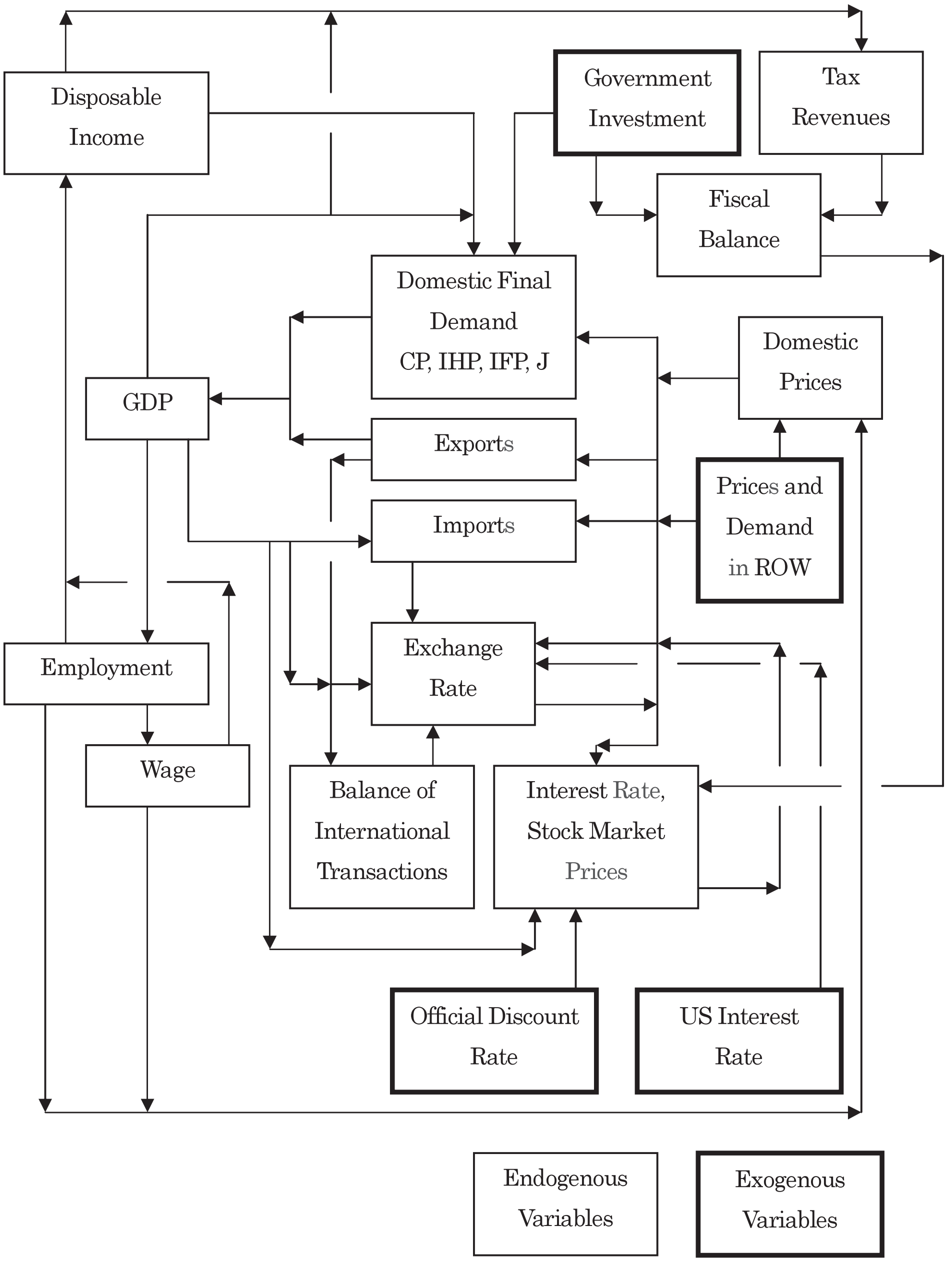


Table 5.1 MAPE Values in the Final Test

Range of MAPE values	Frequency
Within 3%	36
3–5%	13
5–10%	16
10–100%	9
100% and more	3

Table 5.2 MAPE Values of the Main Endogenous Variables

Unit: %

GDP	1.208	GDPV	1.346	PGDP	0.478
CP	0.859	CPV	1.105	PCP	0.491
CG	0.764	CGV	-	PCG	0.767
IHP	3.133	IHPV	3.472	PIHP	0.706
IFP	5.461	IFPV	5.441	PIFP	0.744
IG	0.847	IGV	-	PIG	0.834
XGS	1.527	XGSV	3.199	PXGS	2.260
MGS	4.826	MGSV	6.236	PMGS	3.670
DPI	0.653	M2CD	1.850	FXS	3.676
UR	2.573	LE	0.075	LW	0.294
YDV	0.994	GDPP	0.211	CU	2.244

Figure 5.1 Explanatory Performances of Main Variables in Final Test

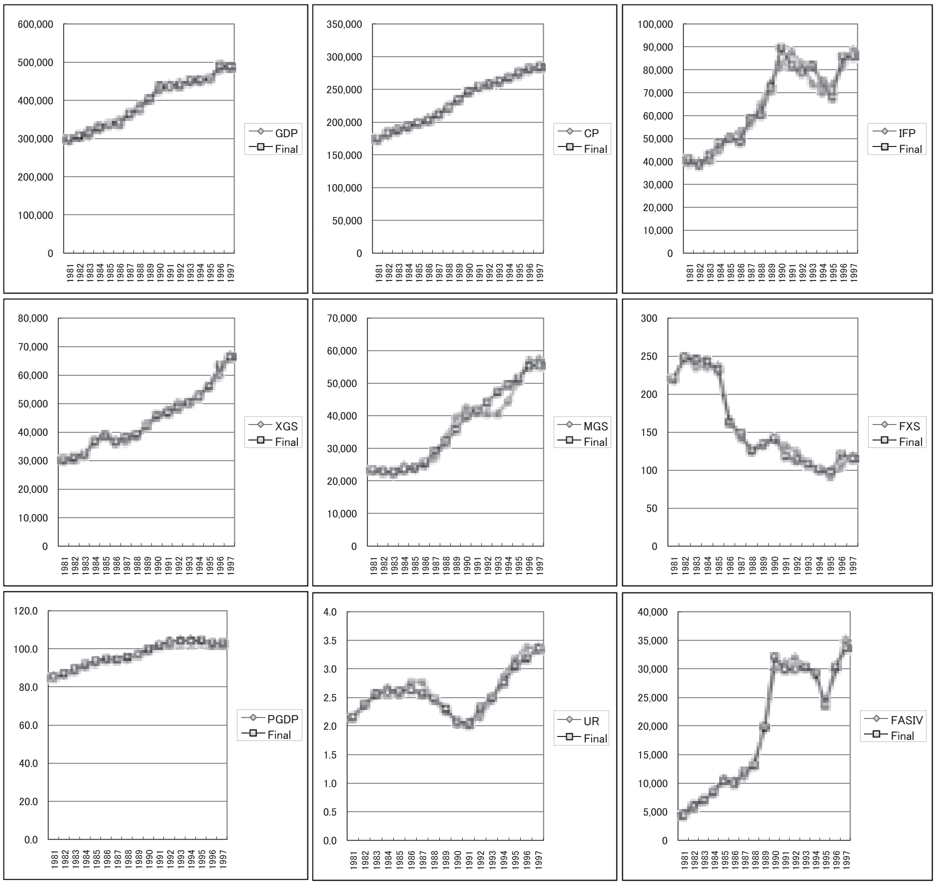


Figure 5.2 GDP Performance in the Initial Value Test

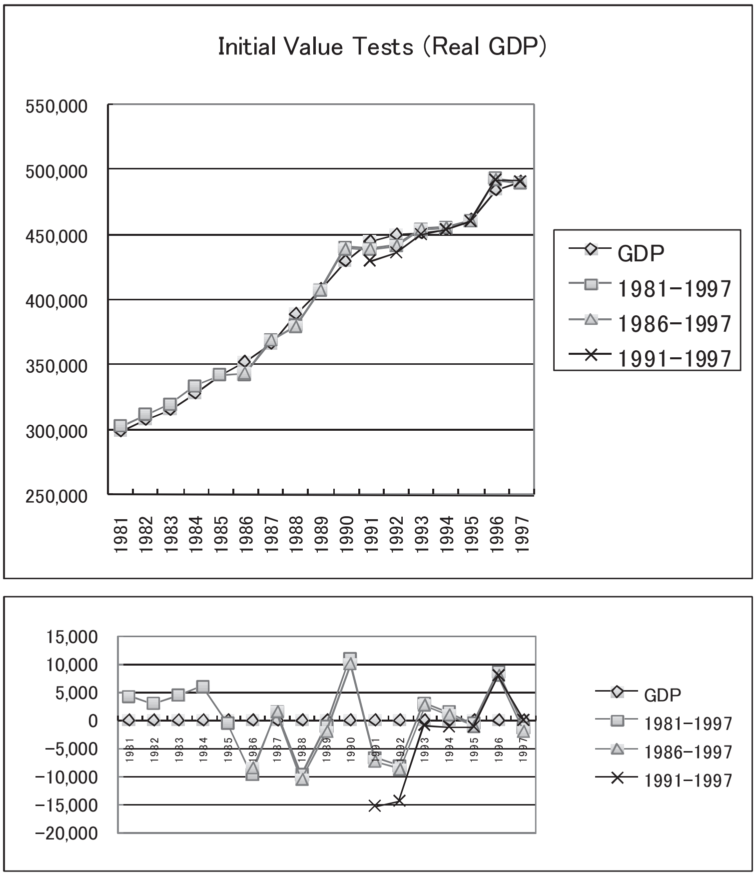
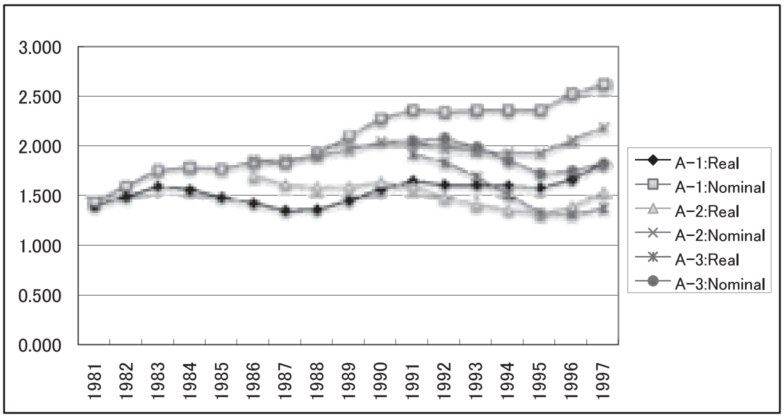
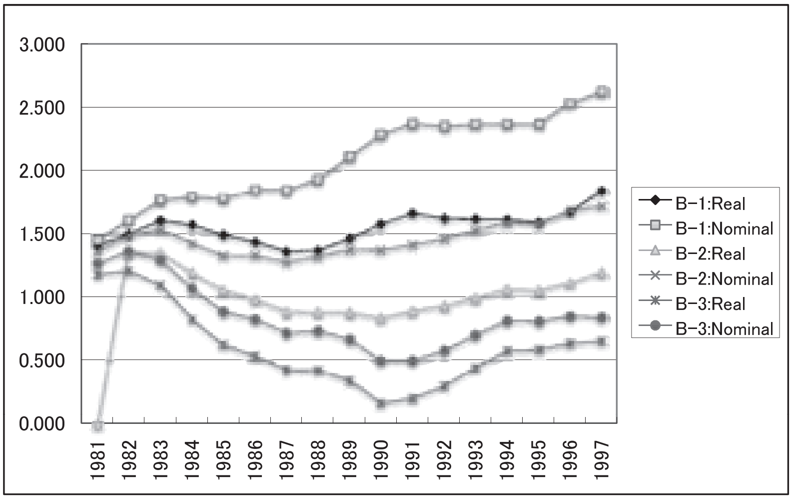


Figure 6.1 Public Investment Multipliers: GDP



	A-1:Real	A-1:Nominal	A-2:Real	A-2:Nominal	A-3:Real	A-3:Nominal
1981	1.415	1.454				
1982	1.502	1.610				
1983	1.609	1.769				
1984	1.575	1.797				
1985	1.497	1.783				
1986	1.441	1.852	1.714	1.876		
1987	1.367	1.847	1.629	1.879		
1988	1.375	1.934	1.605	1.918		
1989	1.466	2.111	1.606	1.973		
1990	1.581	2.287	1.652	2.056		
1991	1.664	2.371	1.606	2.059	1.933	2.064
1992	1.625	2.351	1.498	1.990	1.849	2.089
1993	1.622	2.368	1.427	1.958	1.708	2.004
1994	1.616	2.368	1.377	1.940	1.520	1.866
1995	1.596	2.368	1.341	1.941	1.343	1.738
1996	1.679	2.533	1.403	2.071	1.328	1.763
1997	1.845	2.628	1.555	2.197	1.389	1.839

Figure 6.2 Public Investment Multipliers: GDP



	B-1:Real	B-1:Nominal	B-2:Real	B-2:Nominal	B-3:Real	B-3:Nominal
1981	1.415	1.454	0.000	1.366	1.185	1.275
1982	1.502	1.610	1.359	1.490	1.213	1.367
1983	1.609	1.769	1.356	1.536	1.100	1.301
1984	1.575	1.797	1.201	1.432	0.831	1.072
1985	1.497	1.783	1.060	1.333	0.631	0.889
1986	1.441	1.852	0.984	1.336	0.543	0.830
1987	1.367	1.847	0.890	1.281	0.431	0.723
1988	1.375	1.934	0.886	1.327	0.429	0.738
1989	1.466	2.111	0.883	1.380	0.346	0.674
1990	1.581	2.287	0.840	1.377	0.168	0.505
1991	1.664	2.371	0.895	1.419	0.204	0.505
1992	1.625	2.351	0.936	1.466	0.305	0.585
1993	1.622	2.368	0.996	1.531	0.448	0.707
1994	1.616	2.368	1.066	1.591	0.585	0.818
1995	1.596	2.368	1.056	1.587	0.592	0.814
1996	1.679	2.533	1.117	1.685	0.643	0.853
1997	1.845	2.628	1.203	1.723	0.660	0.845

Table 6.1 Multiplier Analysis

	Control	Case-1 IGV+0.01 *GDPV	Case-2 RDIS +1.0	Case-3 WPX 10%up	Case-4 WYVI 10%up	Case-5 USRGB +1.0
GDP(%)						
1991	431,096.0	1.909	-0.024	1.087	2.062	-0.223
1992	436,392.5	1.794	0.915	1.078	2.049	-0.389
1993	451,256.6	1.655	1.286	0.980	1.856	-0.464
1994	454,092.5	1.460	1.464	0.986	1.854	-0.471
1995	460,762.2	1.282	1.287	0.848	1.582	-0.192
1996	493,236.9	1.297	1.792	1.024	1.918	-0.368
1997	492,099.8	1.322	1.997	0.940	1.737	-0.453
CP(%)						
1991	255,718.1	0.473	0.423	0.176	0.335	-0.071
1992	258,998.8	0.494	1.179	0.117	0.224	-0.118
1993	264,000.7	0.400	1.422	0.110	0.211	-0.096
1994	269,982.3	0.288	1.611	0.142	0.273	-0.015
1995	277,883.2	0.187	1.699	0.172	0.335	0.125
1996	282,993.3	0.151	1.797	0.258	0.501	0.134
1997	285,878.7	0.121	1.629	0.298	0.577	0.194
CG(%)						
1991	39,837.3	-0.306	0.048	-0.184	-0.347	-0.015
1992	40,478.3	-0.627	0.005	-0.351	-0.662	-0.035
1993	41,401.5	-0.681	-0.153	-0.280	-0.528	0.012
1994	42,209.4	-0.721	-0.278	-0.145	-0.268	0.145
1995	42,944.1	-0.735	-0.337	0.051	0.112	0.276
1996	42,928.0	-0.738	-0.461	0.199	0.397	0.412
1997	43,582.8	-0.763	-0.716	0.344	0.680	0.609
IFP(%)						
1991	77,236.0	3.884	-1.595	2.659	5.048	-1.360
1992	75,642.8	3.513	1.377	2.644	5.021	-2.483
1993	79,680.4	2.910	2.949	2.359	4.457	-2.806
1994	73,033.9	2.165	3.655	2.891	5.426	-2.999
1995	67,634.4	1.273	2.250	2.599	4.862	-1.218
1996	84,894.5	1.164	4.778	3.154	5.956	-1.673
1997	85,885.3	1.160	5.997	3.101	5.821	-1.635
IG(%)						
1991	29,720.3	14.275	0.109	-0.137	-0.257	-0.099
1992	33,936.9	12.448	0.189	-0.154	-0.290	-0.192
1993	39,195.5	11.062	0.157	-0.043	-0.078	-0.120
1994	39,862.2	10.809	0.052	0.174	0.339	0.102
1995	39,502.3	10.918	-0.051	0.491	0.955	0.383
1996	42,545.1	10.887	-0.255	0.709	1.376	0.640
1997	38,189.0	12.013	-0.615	1.036	2.017	0.983
IHP(%)						
1991	22,561.6	1.276	1.079	0.490	0.928	-0.170
1992	22,515.0	1.162	2.974	0.246	0.473	-0.252
1993	22,331.6	0.783	3.329	0.161	0.311	-0.164
1994	23,005.0	0.398	3.334	0.204	0.394	0.044
1995	24,111.9	0.126	3.120	0.219	0.432	0.358
1996	25,924.9	0.063	2.928	0.375	0.732	0.256
1997	21,690.0	0.016	2.605	0.473	0.919	0.371
XGS(%)						
1991	47,669.0	0.225	-0.342	5.123	9.718	0.367
1992	49,885.3	0.324	-0.633	5.770	10.967	0.560
1993	51,949.3	0.567	-0.504	5.485	10.392	0.175
1994	54,732.5	0.806	-0.255	4.962	9.338	-0.443
1995	58,723.2	0.974	-0.067	4.339	8.075	-1.032
1996	65,884.2	0.934	0.299	4.183	7.783	-1.315
1997	69,244.5	1.084	1.049	3.593	6.582	-1.874

Table 6.1 Multiplier Analysis (Continued)

	Control	Case-1 IGV+0.01 *GDPV	Case-2 RDIS +1.0	Case-3 WPX 10%up	Case-4 WYVI 10%up	Case-5 USRGB +1.0
MGS(%)						
1991	44,246.6	1.809	0.184	0.980	1.860	-0.450
1992	45,978.1	1.592	1.455	1.047	1.992	-0.874
1993	48,589.6	1.235	1.992	1.239	2.355	-0.906
1994	49,872.7	0.747	2.172	1.751	3.334	-0.546
1995	51,200.3	0.258	1.910	2.328	4.463	0.324
1996	54,079.6	0.061	2.143	3.107	5.986	0.730
1997	54,050.3	-0.178	1.714	3.836	7.426	1.426
GDPV(%)						
1991	441,833.5	2.069	-0.033	1.121	2.128	-0.226
1992	454,169.0	2.087	0.924	1.163	2.210	-0.358
1993	473,857.0	2.004	1.315	1.046	1.973	-0.410
1994	477,962.3	1.870	1.544	0.967	1.801	-0.457
1995	488,490.5	1.743	1.425	0.703	1.281	-0.262
1996	518,435.3	1.773	1.933	0.734	1.338	-0.545
1997	518,159.9	1.836	2.244	0.484	0.841	-0.763
PGDP						
1991	102.5	0.161	-0.009	0.035	0.067	-0.003
1992	104.1	0.299	0.009	0.088	0.163	0.032
1993	105.0	0.360	0.030	0.069	0.120	0.057
1994	105.3	0.425	0.083	-0.020	-0.054	0.015
1995	106.0	0.483	0.144	-0.153	-0.314	-0.075
1996	105.1	0.495	0.146	-0.302	-0.598	-0.187
1997	105.3	0.534	0.255	-0.475	-0.927	-0.328
LE(%)						
1991	6,366.7	0.051	0.001	0.026	0.049	-0.008
1992	6,415.6	0.104	0.034	0.056	0.104	-0.022
1993	6,437.3	0.146	0.076	0.081	0.151	-0.035
1994	6,447.6	0.185	0.124	0.110	0.202	-0.044
1995	6,446.9	0.218	0.168	0.136	0.248	-0.038
1996	6,481.7	0.239	0.213	0.158	0.287	-0.038
1997	6,544.7	0.263	0.258	0.175	0.317	-0.040
LW(%)						
1991	4,992.6	0.041	0.001	0.021	0.040	-0.007
1992	5,110.0	0.105	0.027	0.056	0.104	-0.021
1993	5,188.0	0.172	0.074	0.094	0.174	-0.039
1994	5,237.3	0.237	0.137	0.136	0.252	-0.055
1995	5,263.9	0.298	0.205	0.180	0.330	-0.059
1996	5,300.4	0.348	0.276	0.220	0.402	-0.062
1997	5,360.3	0.391	0.349	0.255	0.463	-0.065
UR						
1991	2.1	-0.050	-0.001	-0.026	-0.048	0.008
1992	2.5	-0.102	-0.033	-0.054	-0.102	0.022
1993	2.7	-0.143	-0.074	-0.079	-0.147	0.034
1994	3.0	-0.179	-0.121	-0.106	-0.196	0.042
1995	3.3	-0.211	-0.162	-0.131	-0.240	0.037
1996	3.4	-0.231	-0.205	-0.153	-0.277	0.037
1997	3.6	-0.253	-0.249	-0.169	-0.306	0.039
W(%)						
1991	49.2	0.730	-0.058	0.427	0.807	-0.029
1992	49.7	0.777	0.216	0.441	0.837	-0.042
1993	50.6	0.803	0.357	0.356	0.672	-0.099
1994	51.6	0.795	0.460	0.248	0.461	-0.201
1995	53.0	0.772	0.436	0.042	0.061	-0.235
1996	54.5	0.785	0.680	-0.017	-0.051	-0.410
1997	54.2	0.816	0.903	-0.207	-0.424	-0.596

Table 6.1 Multiplier Analysis (Continued)

	Control	Case-1 IGV+0.01 *GDPV	Case-2 RDIS +1.0	Case-3 WPX 10%up	Case-4 WYVI 10%up	Case-5 USRGB +1.0
M2CD(%)						
1991	491,669.8	1.869	-0.549	1.012	1.921	-0.207
1992	504,247.3	1.881	0.239	1.071	2.033	-0.335
1993	525,727.4	1.806	0.504	0.991	1.869	-0.390
1994	528,404.8	1.692	0.720	0.925	1.724	-0.430
1995	540,125.5	1.567	0.584	0.691	1.262	-0.244
1996	568,108.2	1.602	1.014	0.730	1.334	-0.487
1997	569,047.3	1.668	1.364	0.498	0.872	-0.663
RGB						
1991	5.7	0.268	0.818	-0.030	-0.056	0.007
1992	5.1	0.233	1.006	-0.060	-0.112	0.022
1993	3.6	0.158	1.036	-0.056	-0.105	0.030
1994	4.7	0.208	1.348	-0.096	-0.177	0.049
1995	3.0	0.168	1.496	-0.087	-0.161	0.010
1996	3.0	0.177	1.500	-0.109	-0.201	-0.003
1997	2.2	0.134	1.053	-0.095	-0.176	-0.014
FXS(%)						
1991	125.6	0.796	-1.349	0.721	1.355	1.477
1992	123.2	1.062	-2.308	-0.277	-0.525	2.006
1993	120.0	1.990	-1.624	-1.742	-3.293	0.342
1994	115.4	2.809	-0.734	-3.486	-6.575	-1.839
1995	113.0	3.341	-0.143	-5.417	-10.192	-3.740
1996	137.0	3.072	1.168	-5.611	-10.480	-4.441
1997	131.9	3.710	3.947	-7.625	-14.222	-6.393
SBCV(%)						
1991	94,930.3	-0.871	-0.181	1.823	3.466	1.570
1992	104,584.7	-1.825	-1.332	3.818	7.252	3.774
1993	111,496.7	-2.659	-3.005	5.845	11.064	6.248
1994	119,191.7	-3.184	-4.675	7.676	14.463	8.441
1995	127,272.6	-3.522	-6.397	9.361	17.539	10.149
1996	135,479.8	-3.764	-8.350	10.952	20.425	11.623
1997	148,374.3	-3.813	-10.096	11.799	21.897	12.834
SBCPV(%)						
1991	-39,360.2	2.065	0.430	-4.321	-8.218	-3.721
1992	-48,521.3	3.831	2.814	-8.018	-15.234	-7.933
1993	-44,547.9	6.407	7.306	-14.105	-26.706	-15.106
1994	-39,942.9	9.004	13.400	-21.806	-41.100	-24.035
1995	-44,599.7	9.343	17.308	-25.053	-46.950	-27.202
1996	-62,440.0	7.417	16.936	-21.898	-40.839	-23.241
1997	-82,074.3	6.092	16.791	-19.220	-35.647	-20.949
SBGV(%)						
1991	-43,223.6	-7.599	-0.418	1.546	2.929	-0.175
1992	-37,452.5	-15.881	0.412	4.921	9.318	-0.862
1993	-42,121.9	-19.942	3.201	7.640	14.436	-2.128
1994	-49,078.3	-21.941	6.786	9.599	18.068	-3.715
1995	-65,288.5	-20.293	8.871	9.477	17.740	-4.330
1996	-85,309.5	-18.808	10.710	9.218	17.170	-4.697
1997	-99,737.7	-18.889	13.551	9.615	17.808	-5.472
NWHV(%)						
1991	2,333,267.0	-0.010	-0.349	0.070	0.134	-0.023
1992	2,299,689.6	-0.002	-0.791	0.168	0.317	-0.060
1993	2,278,030.6	0.020	-0.788	0.163	0.306	-0.066
1994	2,244,773.1	-0.010	-0.965	0.169	0.315	-0.054
1995	2,210,779.3	-0.044	-1.324	0.186	0.343	0.003
1996	2,232,080.3	0.019	-0.989	0.148	0.271	0.075
1997	2,142,389.8	-0.007	-1.280	0.232	0.425	0.132

Appendix A: Listing of Estimated Japan Model

[1] Aggregate Demand Block
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(1) Gross Domestic Product, Real GDP
GDP=CP+CG+IHP+IFP+IG+J+BF

(2) Private Final Consumption Expenditure, Real: CP Sample: 1981- 1997
CP =-9452.323 + 0.8389387*YDV/PCP*100 + 0.0106060*NWHV(-1)/PCP*100-3651.967*D81
(-4.38) (60.67) (9.238) (-4.00)
-2526.366*D9192 + 3043.1103*D97
(-3.53) (3.191)
RR: .9996727, RRADJ: .999524, STER: 806.6648, D-W: 2.205897

(3) Government Final Consumption Expenditure, Real: CG
CG=CGV/PCG*100

(4) Private Residential Investment, Real: IHP Sample: 1981- 1997
IHP = 4706.6633 + 0.1915761*YDV/PCP*100 -0.172835*KHP(-1)
(3.005) (2.876) (-2.04)
-2313.818*(D8386-D8790) + 1479.5528*(D96-D97)
(-6.51) (2.405)
RR: .9639992 RRADJ: .9519989 STER: 756.6066 D-W: 2.34772

(5) Private Business Fixed Investment, Real: IFP Sample: 1981- 1997
IFP/KFP(-1)=-0.110979+0.3452444*GDP/KFP(-1)-2228.068*PIFP*(4.5+RGB)/PGDP/KFP(-1)
(-7.36) (11.27) (-6.55)
+ 1.1453948*(FASIV-FLBIV)/(PIFP/100)/KFP(-1) + 0.0121792*D81
(8.904) (2.790)
RR: .9558048 RRADJ: .9410731 STER: 3.322581E-03 D-W: 1.947662

(6) Public Investment , Real: IG
IG=IGV/PIG*100

(7) Changes in Inventories, Real: J Sample: 1981- 1997
J/KJ(-1) = -0.179306 + 0.0373801*GDP/KJ(-1) - 0.018206*#D9297
(-3.97) (4.568) (-3.68)
RR: .6441846 RRADJ: .5933538 STER: 9.010761E-03 D-W: 1.673084

(8) Exports of Goods and Services, Real: XGS Sample: 1981- 1997
log(XGS) = 2.0910231 + 0.9346727*log(WYVI) - 0.503736*log(PXGS/FXS/WPX)
(4.479) (9.680) (-9.61)

+ 0.1736349*log(XGS(-1)) -0.059642*(D82+D83)
(2.039) (-4.13)
RR: .9967704 RRADJ: .9956939 STER: 1.529369E-02 D-W: 2.29813

(9) Imports of Goods and Services, Real: MGS Sample: 1981- 1997
log(MGS/GDP) = -0.411794 -0.154389*LOG(PMGS/PGDP) + 0.8199673*log(MGS(-1)/GDP(-1))
(-1.50) (-2.91) (7.274)
RR: .9025846 RRADJ: .8886681 STER: 5.628814E-02 D-W: 1.357348

(10) Net Exports of Goods and Services, Real: BF
BF=XGS-MGS

(11) Gross Domestic Product, Nominal: GDPV
GDPV=CPV+CGV+IHPV+IFPV+IGV+JV+BFV

(12) Private Final Consumption Expenditure, Nominal: CPV
CPV=CP*PCP/100

(13) Private Residential Investment, Nominal: IHPV
IHPV=IHP*PIHP/100

(14) Private Business Fixed Investment, Nominal: IFPV
IFPV=IFP*PIFP/100

(15) Changes in Inventories, Nominal: JV
JV=(KJ*PJ-KJ(-1)*PJ(-1))/100-JVA

(16) Exports of Goods and Services, Nominal: XGSV
XGSV=XGS*PXGS/100

(17) Imports of Goods and Services, Nominal: MGSV
MGSV=MGS*PMGS/100

(18) Net Exports of Goods and Services, Nominal: BFV
BFV=XGSV-MGSV

(19) Private Residential Stock, Real: KHP Sample: 1981- 1997
KHP-IHP = 663.61388 + 0.9195424*KHP(-1)
(0.609) (173.0)
RR: .9994992 RRADJ: .9994658 STER: 630.7441 D-W: 2.256967

(20) Private Gross Capital Stock, Real: KFP Sample: 1981- 1997
KFP-IFP = -443.0260 + 0.9570473*KFP(-1) + 20473.897*D85
(-0.12) (191.5) (4.783)
RR: .9996356 RRADJ: .9995835 STER: 4036.28 D-W: 2.011388

(21) Private Inventory Stock, Real: KJ
KJ=J+KJ(-1)

[2] Production and Employment Block
----

(22) Unemployment Rate: UR Sample: 1981- 1997
log(UR) = 9.8489574 -1.921125*log(GDP/LF) + 2.2097017*log(W/PGDP)
(2.002) (-2.14) (1.481)
+ 0.7865822*log(UR(-1)) + 0.1525661*D9297
(8.116) (3.850)
RR: .9394418 RRADJ: .9192557 STER: 4.396002E-02 D-W: 2.256675

(23) Employed Persons: LE
LE=LF*(1-UR/100)

(24) Employees: LW Sample: 1981- 1997
LW = - 1685.654 + 0.6327749*LE + 0.5480106*LW(-1)
(-11.3) (12.32) (14.82)
RR: .9993235 RRADJ: .9992269 STER: 13.1561 D-W: 1.468631

(25) Full Employment GDP: GDPP Sample: 1981- 1997
log(GDP/(LE*LH)) = -25.26636 + 0.3028601*log(KFP(-1)*CU/(LE*LH)) + 0.0115907*TIME
(-2.01) (2.806) (1.779)
RR: .9918765 RRADJ: .990716 STER: 1.457375E-02 D-W: .8566796

log(GDPP)= -25.26636+0.3028601*log(KFP(-1)*Cuop/(LF*LHop)) +log(LF*LHop) +0.0115907*TIME

(26) Operation Rate Index: CU Sample: 1981- 1997
log(CU) = 4.7732724 + 0.5733957*log(GDP/GDPP) + 3.1966759*log(LE/LF) + 1.9541754* log(LH/LHop)
(226.9) (2.341) (4.494) (8.015)
-0.034565*D8182 + 0.0317375*D8485 + 0.0433079*D8891 -0.031205*(D96-D97)
(-3.88) (4.628) (5.509) (-5.95)
RR: .9885988 RRADJ: .9797311 STER: 7.101923E-03 D-W: 2.045548

(27) Labor Hour Index: LH Sample: 1981- 1997

log(LH) = 4.6714239 -0.001848*TIME + 0.8054438*log(LH(-1)) -0.024948*D93
(2.305) (-2.32) (8.369) (-2.96)
RR: .9738628 RRADJ: .9678311 STER: 7.960671E-03 D-W: 1.072806

[3] Price and Wage Block
----

(28) Per Capita Compensation of Employees: W Sample: 1981- 1997

log(W/W(-1)) = 0.0133856 + 0.3102529*log(GDP/LW/(GDP(-1)/LW(-1)))
(6.663) (5.124)
+ 0.7362395*log(PCP/PCP(-1)) + 0.0132932*D81
(7.657) (2.898)
+ 0.0107880*(D9091-D9293) -0.014959*D9697
(5.601) (-5.55)
RR: .9698518 RRADJ: .956148 STER: 3.393291E-03 D-W: 2.767105

(29) Wholesale Price Index, Domestic: DPI Sample: 1981- 1997

log(DPI) = 3.6954662 + 0.1826948*log(PMGS) + 0.1400915*log(W)
(22.95) (23.18) (6.760)
-0.096158*log(GDP/LW) + 0.0116254*D81 + 0.0159272*D86 + 0.0129939*D9193
(-2.70) (3.368) (4.838) (5.698)
-0.035922*D9697
(-11.9)
RR: .9975345, RRADJ: .9956168, STER: 2.764523E-03, D-W: 2.803279

(30) GDP, Deflator: PGDP

PGDP=GDPV/GDP*100

(31) Private Final Consumption Expenditure, Deflator: PCP Sample: 1981- 1997

log(PCP) = 0.1695227 + 0.2084100*log(DPI) + 0.2667133*log(W)
(0.480) (4.421) (6.321)
+ 0.5325155*log(PCP(-1))
(7.145)
RR: .9973971 RRADJ: .9967964 STER: 4.161163E-03 D-W: 1.929029

(32) Government Final Consumption Expenditure, Deflator: PCG Sample: 1981- 1997

log(PCG)-log((DPI+DPI(-1))/2) = 0.6183195 + 0.8115032*log((W+W(-1))/2)-log((DPI+DPI(-1))/2)
(87.57) (101.1)
+ 0.0306124*D81 -0.019801*D8789 + 0.0122459*D9293
(5.243) (-6.03) (3.052)
RR: .9991017, RRADJ: .9988022, STER: 5.039252E-03, D-W: 2.674841

(33) Private Residential Investment, Deflator: PIHP Sample: 1981- 1997
log(PIHP) = -0.530973 + 0.2810830*log(DPI) + 0.4259298*log(W)
(-1.87) (5.389) (10.66)
+ 0.4768722*log(PIHP(-1)) + 0.0189279*D8182 -0.017169*D86
(9.585) (3.758) (-3.55)
+ 0.0204931*D97
(4.148)
RR: .9985159 RRADJ: .9976255 STER: 4.421548E-03 D-W: 2.373049

(34) Private Business Fixed Investment, Deflator: PIFP Sample: 1981- 1997
log(PIFP) = -0.410400 + 0.3142561*log(DPI) + 0.7694341*log(PIFP(-1))
(-1.38) (7.504) (11.86)
+ 0.0199034*D8893 -0.029382*D96
(6.135) (-4.33)
RR: .975307 RRADJ: .967076 STER: 5.883468E-03 D-W: 1.77976

(35) Public Investment, Deflator: PIG Sample: 1981- 1997
log(PIG) = -0.708577 + 0.3718628*log(DPI) + 0.2438606*log(W)
(-1.80) (4.051) (4.022)
+ 0.5740280*log(PIG(-1)) + 0.0174422*D8892 -0.024843*D96
(5.794) (4.378) (-3.54)
+ 0.0217963*D81
(3.052)
RR: .9924769 RRADJ: .9879631 STER: 6.139712E-03 D-W: 2.582887

(36) Changes in Inventories, Deflator: PJ Sample: 1981- 1997
log(PJ) = -1.919811 + 1.3983668*log(DPI) + 0.0421064*D8184
(-4.82) (16.28) (5.078)
+ 0.0246713*D8790 -0.019978*D93
(4.655) (-2.18)
RR: .9894039 RRADJ: .9858719 STER: 8.620272E-03 D-W: 1.695448

(37) Exports of Goods and Services, Deflator: PXGS Sample: 1981- 1997
log(PXGS)-log(DPI) = -0.199530 + 0.3838061*(log(FXS)-log(DPI))+ 0.0374615*D81 -0.035558*D85
(-30.1) (26.53) (2.322) (-2.14)
+ 0.0414882*D8890 -0.045368*D97
(4.330) (-2.93)
RR: .9886113, RRADJ: .9834347, STER: 1.466584E-02, D-W: 2.033628

(38) Imports of Goods and Services, Deflator: PMGS
PMGS=PMGSD*FXS/144.81

[4] Income Block

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(39) National Income at Factor Cost: NIV

NIV=YWV+YICV+YCV+YIV

(40) Disposable Income, Household: YDV

YDV=YWV+YICV+YIEV+BSSV-CSSV-TYPV+OYDV

(41) Compensation of Employees: YWV

YWV=W*LW

(42) Operation Surplus and Mixed Income: YICV Sample: 1981- 1997

YICV/(LE-LW) = -8.817160 + 0.3491215*W + 0.7772307*YICV(-1)/(LE(-1)-LW(-1))

(-2.15) (2.354) (6.625)

RR: .9782255 RRADJ: .9751149 STER: 1.297089 D-W: 2.580589

(43) Property Income, Private: YIEV Sample: 1981- 1997

YIEV = 6871.3169 + 0.1302554*(RGB+RGB(-1))/200*NWHV(-1) + 0.4190305*YIEV(-1)

(3.567) (7.454) (5.192)

RR: .9453006 RRADJ: .9374864 STER: 1331.239 D-W: 2.207496

(44) Corporate Income Before Dividend Payment: YCV Sample: 1981- 1997

YCV = -31748.96 + 0.1808513*(GDPV-YWV-YICV-YIV) + 377.87208*(CU+CU(-1))/2 + 5944.7483*D8688

(-2.84) (9.335) (3.792) (4.755)

-3645.776*D81 -3425.583*(D95-D96)

(-1.66) (-2.53)

RR: .9340317 RRADJ: .9040461 STER: 1895.668 D-W: 1.346612

(45) Property Income: YIV Sample: 1981- 1997

YIV = 86244.025 + 1.0079344*(YIEV+YIGV) -43.47378*TIME + 0.3846749*(YIV(-1)-YIEV(-1)-YIGV(-1))

(2.632) (179.4) (-2.63) (1.530)

RR: .9998225 RRADJ: .9997815 STER: 89.08795 D-W: 1.61247

(46) Stock valuation Adjustment: JVA Sample: 1981- 1997

JVA = 42.290174 + 1.0215770*(PJ-PJ(-1))*KJ(-1)/100

(1.352) (62.17)

RR: .9961348 RRADJ: .9958771 STER: 117.9813 D-W: 1.969937

(47) Net Assets of Household: NWHV Sample: 1981- 1997
NWHV = -126801.2 + 0.9319499*(NWHV(-1)+YDV-CPV)+ 223502.42*PSHARE/PSHARE(-1)
(-0.99) (29.46) (2.782)
+ 214592.26*D8790
(6.546)
RR: .9905623 RRADJ: .9883843 STER: 56386.3 D-W: 2.017989

[5] Government Fiscal Block
----

(48) Private Income Tax: TYPV Sample: 1981- 1997
TYPV = -5817.391 + 0.1228407*(YWV+YICV+YIEV+YWV(-1)+YICV(-1)+YIEV(-1))/2
(-6.19) (32.50)
+ 4121.5570*(D9091+D92/2) -6784.908*(D94/2+D9597)
(7.929) (-11.8)
RR: .9939447, RRADJ: .9925473, STER: 582.3293, D-W: 2.070471

(49) Private Corporate Tax: TYCV Sample: 1981- 1997
TYCV = -14577.60 + 0.3197767*(YCV+JVA+YCV(-1)+JVA(-1))/2 + 152.59262*(CU+CU(-1))/2
(-2.68) (4.473) (2.854)
+ 0.4561278*TYCV(-1)
(4.922)
RR: .9552486 RRADJ: .9449213 STER: 1001.801 D-W: 1.676541

(50) I ndirect Tax: TAXIV Sample: 1981- 1997
TAXIV = -8273.725 + 0.1207058*(CPV+CGV+IHPV) + 0.0571338*(IFPV+MGSV)
(-3.49) (15.09) (2.491)
-0.007563*(D8997)*(CPV+CGV+IHPV)
(-2.19)
RR: .9926119 RRADJ: .990907 STER: 730.2461 D-W: 1.5356

(51) Tax Revenues, Total: TAXV
TAXV=TYPV+TYCV+TAXIV

(52) Property Income, General Government: YIGV Sample: 1981- 1997
YIGV = 1909.9277 -36845.96*(RGB+RGB(-1))/200 + 0.0621992*SBGV(-1)
(2.144) (-4.94) (7.069)
+ 1608.9563*D91 -1726.123*D93 + 2376.2912*D94
(3.329) (-2.90) (4.236)
RR: .9387217 RRADJ: .9108679 STER: 454.8862 D-W: 1.041218

(53) Social Security Contribution: CSSV Sample: 1981- 1997

CSSV = -13339.88 + 0.1947727*(YWV+YICV)

(-8.55) (32.21)

RR: .9857491 RRADJ: .984799 STER: 1391.13 D-W: .9830177

(54) Social Security Benefits: BSSV Sample: 1981- 1997

BSSV = -5230.828 + 0.0388042*(W*POP65) + 0.9165257*(W*UR*LF/100) + 0.0437236*YDV

(-1.24) (2.899) (3.136) (1.008)

RR: .9970119 RRADJ: .9963223 STER: 780.7707 D-W: 2.450601

(55) Fiscal Balance, General Government: BGV

BGV=TAXV+CSSV+YIGV+OTGV-(CGV+IGV+BSSV+SUBV)

(56) Accumulated Fiscal Balance, General Government: SBGV

SBGV=SBGV(-1)+BGV

[6] Monetary Block

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(57) Money Supply: M2CD Sample: 1981- 1997

M2CD = -82390.40 + 1.0092333*GDPV + 0.0592744*NWHV(-1) -2060.513*RCD

(-2.60) (6.868) (2.869) (-1.02)

RR: .996444 RRADJ: .9956234 STER: 8145.979 D-W: .9987453

(58) CD rate: RCD Sample: 1981- 1997

RCD = -40.92073 + 1.2443157*RDIS + 8.9747608*log(PCP)

(-5.57) (20.43) (5.721)

RR: .9774761 RRADJ: .9742584 STER: .312153 D-W: 1.099869

(59) Yield Rate of Bonds: RGB Sample: 1981- 1997

log(RGB) = 0.2880081 + 0.7228124*log(RCD) -5.537456*(SBGV-SBGV(-1))/GDPV

(9.596) (29.60) (-17.3)

+ 0.1516270*log(RGB(-1)) + 0.2202326*(D86/2+D8788) -0.141117*(D93-D94)

(4.672) (12.79) (-9.86)

-0.277834*D97

(-12.2)

RR: .9987029, RRADJ: .9979247, STER: 1.838331E-02, D-W: 2.340256

(60) Tokyo Stock Price Index: PSHARE Sample: 1981- 1997
PSHARE/PGDP = -8.877067 + 20.265731*PLAND/PGDP
(-1.50) (4.489)
+ 270.76357*(YCV+YCV(-1))/2/(KFP(-1)*PIFP/100) -1.473844*(RGB+RGB(-1))/2
(4.286) (-4.09)
-2.051708*(D85-D86-D87) + 5.9154899*D88 + 11.008247*D89 -6.140239*D97
(-2.19) (3.025) (5.922) (-3.32)
RR: .9662606, RRADJ: .9400188, STER: 1.45212, D-W: 2.093533

(61) Price Earning Rate in Tokyo Stock Exchange Market, 1st Section: PER Sample: 1982- 1997
PER = 355.21752 + 34.610584*PSHARE/PSHARE(-1) -364.3186*GDPV/GDPV(-1) + 0.8332999*PER(-1)
(4.602) (4.234) (-5.00) (8.985)
-41.53550*D97
(-5.61)
RR: .9202752 RRADJ: .8912843 STER: 6.351111 D-W: 2.627827

(62) Land Price Index of City Area, Residential Area: PLAND Sample: 1981- 1997
PLAND = 3.6317195 + 0.0078188*(GDP+GDP(-1))/2000 + 5.4351815*NWHV(-1)/GDPV
(3.321) (1.435) (14.39)
+ 0.6600168*PLAND(-1) + 5.6424476*D90 + 8.4352830*D91 ;
(30.24) (9.405) (15.68)
RR: .9994408, RRADJ: .9991866, STER: .4511815, D-W: 2.451674

[7] Balance of Payment and Exchange Rate Block
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(63) Factor Income from Abroad: RTRIV Sample: 1981- 1997
RTRIV = -368.7816 + 0.5254585*USRGB/100*FASV(-1) + 0.4482672*RTRIV(-1)
(-0.80) (5.884) (5.618)
+ 2588.7346*D8990 + 8063.4146*D9697 + 3056.5377*D95
(4.588) (10.90) (4.294)
RR: .9954039, RRADJ: .9933147, STER: 653.4304, D-W: 1.707574

(64) Factor Income to Abroad: PTRIV Sample: 1981- 1997
PTRIV = -2993.002 + 446.96953*(RGB+RGB(-1))/2 + 0.0722598*FLBV(-1)
(-3.11) (3.697) (31.39)
+ 1207.8142*D8182 -1182.959*D8687 + 1917.5372*D8990 + 3129.0285*D95
(3.381) (-3.80) (6.701) (7.337)
+ 8787.4428*D9697
(20.71)
RR: .9980928, RRADJ: .9966094, STER: 355.4718, D-W: 2.289276

(65) Current Balance: BCV
BCV=BFV+(RTRIV-PTRIV)+ERRBCV

(66) Accumulated Current balance: SBCV
SBCV=SBCV(-1)+BCV

(67) External Assets, Total: FASV
FASV=FLBV-SBCPV

(68) External Assets, Securities: FASMV Sample: 1981- 1997
log(FASMV/GDPV) = -0.630835 + 0.0384126*(USRGB+USRGB(-1)-RGB-RGB(-1))/2
(-6.95) (1.590)
+ 0.8846724*log(FASV/GDPV) + 0.3765197*log(FASMV(-1)/GDPV(-1))
(4.493) (3.007)
+ 0.2305797*D8486 + 0.0985750*D96
(6.293) (1.684)
RR: .9958243 RRADJ: .9939263 STER: 5.224095E-02 D-W: 2.791022

(69) External Assets, Direct Investment: FASIV Sample: 1981- 1997
log(FASIV/GDPV) = -0.670782 -0.112457*log(FXS(-1)) + 0.3654967*log(FASV/GDPV)
(-3.50) (-2.73) (9.766)
+ 0.4748550*log(FASIV(-1)/GDPV(-1)) -0.075219*(D81-D82) -0.183944*(D8688-D90)
(12.86) (-3.78) (-11.8)
-0.227759*D95
(-7.21)
RR: .9972569, RRADJ: .9956111, STER: 2.781259E-02, D-W: 2.119172

(70) External Assets, Other: FASOV
FASOV=FASV-(FASMV+FASIV)

(71) External Liabilities, Total FLBV
FLBV=FLBMV+FLBIV+FLBOV

(72) External Liabilities, Securities: FLBMV Sample: 1981- 1997
log(FLBMV/GDPV) = -0.528415 -0.067628*(USRGB-RGB) + 0.2630508*D89
(-5.13) (-3.36) (4.187)
+ 0.6496117*log(FLBMV(-1)/GDPV(-1)) + 0.2128308*D9697
(11.33) (4.099)
RR: .9707538 RRADJ: .9610051 STER: 6.021139E-02 D-W: 2.261943

(73) External liabilities, Direct Investment: FLBIV Sample: 1981- 1997
log(FLBIV/GDPV) = -11.38855 + 0.6884338*log(GDP) + 0.2534822*log(FXS)
(-2.80) (2.677) (1.956)
-0.225230*D89 + 0.5140845*D95 + 0.7702992*log(FLBIV(-1)/GDPV(-1))
(-3.46) (7.206) (9.358)
RR: .9653869 RRADJ: .9496537 STER: 6.147034E-02 D-W: 3.125403

(74) External Liabilities, Other: FLBOV Sample: 1981- 1997
FLBOV = -4243.992 + 0.6791600*FLBV + 11547.701*D8789 + 17764.355*D90
(-3.03) (74.29) (7.610) (6.891)
-5503.465*D94
(-2.22)
RR: .9982669 RRADJ: .9976892 STER: 2330.749 D-W: 2.077502

(75) Accumulated Capital balance: SBCPV
SBCPV=FCR-(SBCV+FSD)

(76) Foreign Exchange Reserves: FCR Sample: 1981- 1997
log(FCR) = -1.392601 + 0.1774560*log(SBCV) + 0.9422245*log(FCR(-1))
(-1.27) (2.090) (7.716)
+ 0.1811784*D8185 -0.322442*D91 + 0.4019448*D87
(1.198) (-2.55) (2.960)
RR: .9599766 RRADJ: .9417841 STER: .1202249 D-W: 1.857335

(77) Exchange Rate: FXS Sample: 1981- 1997
FXS = 193.36560 + 4.0822800*(USRGB+USRGB(-1)-RGB-RGB(-1))/2 -384.5583*SBCV(-1)/GDPV
(15.97) (1.190) (-13.8)
+ 48.320523*(D81*0.5+D8285) -15.15630*(D88-D90) + 22.526757*(D9697)
(6.594) (-3.45) (3.558)
RR: .9937735 RRADJ: .9909432 STER: 5.199704 D-W: 2.014726

Appendix B: List of Variables

Variables	Code	Endogenous/ Exogenous	Data Source(s)	Data Unit
National Current Surplus	BCV	Endogenous	CAO, SNA	Billion yen
Net Exports of Goods and Services, Real	BF	Endogenous	CAO, SNA	1990 billion yen
Net Exports of Goods and Services, Nominal	BFV	Endogenous	CAO, SNA	Billion yen
Fiscal Balance, General Government	BGV	Endogenous	CAO, SNA	Billion yen
Social Security Benefits	BSSV	Endogenous	CAO, SNA	Billion yen
Government Final Consumption Expenditure, Real	CG	Endogenous	CAO, SNA	1990 billion yen
Government Final Consumption Expenditure, Nominal	CGV	Exogenous	CAO, SNA	Billion yen
Private Final Consumption Expenditure, Real	CP	Endogenous	CAO, SNA	1990 billion yen
Private Final Consumption Expenditure, Nominal	CPV	Endogenous	CAO, SNA	Billion yen
Social Security Contribution	CSSV	Endogenous	CAO, SNA	Billion yen
Operation Rate Index	CU	Endogenous	METI	
Maximal Operation Rate Index	CUop	Exogenous	Estimated	
Wholesale Price Index, Domestic	DPI	Endogenous	METI	1995 = 100
Current Transfer, Other	ERRBCV	Exogenous	CAO, SNA	Billion yen
External Assets, Direct Investment	FASIV	Endogenous	CAO, SNA	Billion yen
External Assets, Securities	FASMV	Endogenous	CAO, SNA	Billion yen
External Assets, Other	FASOV	Endogenous	CAO, SNA	Billion yen
External Assets, Total	FASV	Endogenous	CAO, SNA	Billion yen
Foreign Exchange Reserves	FCR	Endogenous	CAO, SNA	Billion yen
GDP Index of Foreign Countries	FGDPV	Exogenous	Weighted average using the direct investment of Japan	1990 = 100
External Liability, Direct Investment	FLBIV	Endogenous	CAO, SNA	Billion yen
External Liability, Securities	FLBMV	Endogenous	CAO, SNA	Billion yen
External Liabilities, Other	FLBOV	Endogenous	CAO, SNA	Billion yen
External Liabilities, Total	FLBV	Endogenous	CAO, SNA	Billion yen
Producers Price Index of Foreign Countries	FPPI	Exogenous	Weighted average using the GDP of each country	1990 = 100
Bond Yield Rate of Foreign Countries	FRGB	Exogenous	Weighted average using the GDP of each country	%
Adjustment Part in External Account	FSD	Exogenous	CAO, SNA	Billion yen
Exchange rate	FXS	Endogenous	BOJ	Yen/Dollar
Gross Domestic Product, Real	GDP	Endogenous	CAO, SNA	1990 billion yen
Full Employment GDP	GDPP	Endogenous	Estimated	1990 billion yen
Gross Domestic Product, Nominal	GDPV	Endogenous	CAO, SNA	Billion yen
Private Business Fixed Investment, Real	IFP	Endogenous	CAO, SNA	1990 billion yen
Private Business Fixed Investment, Nominal	IFPV	Endogenous	CAO, SNA	Billion yen
Public Investment, Real	IG	Endogenous	CAO, SNA	1990 billion yen
Public Investment, Nominal	IGV	Exogenous	CAO, SNA	Billion yen
Private Residential Investment, Real	IHP	Endogenous	CAO, SNA	1990 billion yen
Private Residential Investment, Nominal	IHPV	Endogenous	CAO, SNA	Billion yen
Changes in Inventories, Real	J	Endogenous	CAO, SNA	1990 billion yen
Changes in Inventories, Nominal	JV	Endogenous	CAO, SNA	Billion yen

Stock Valuation Adjustment, Nominal	JVA	Endogenous	CAO, SNA	Billion yen
Private Gross Capital Stock, Real	KFP	Endogenous	CAO, SNA	1990 billion yen
Private Residential Stock, Real	KHP	Endogenous	CAO, SNA	1990 billion yen
Inventory Stock, Real	KJ	Endogenous	CAO, SNA	1990 billion yen
Employed Persons	LE	Endogenous	MIAC, LES	10,000 persons
Labor Force	LF	Exogenous	MIAC, LFS	10,000 persons
Labor Hour Index	LH	Endogenous	MHLW	1990 = 100
Maximal Labor Hour Index	LHop	Exogenous	Estimated	1990 = 100
Employees	LW	Endogenous	MIAC, LFS	10,000 persons
Money Supply (M2+CD, Average)	M2CD	Endogenous	BOJ, ESM	Billion yen
Imports of Goods and Services, Real	MGS	Endogenous	CAO, SNA	1990 billion yen
Imports of Goods and Services, Nominal	MGSV	Endogenous	CAO, SNA	Billion yen
National Income at Factor Cost	NIV	Endogenous	CAO, SNA	Billion yen
Net Assets of Household	NWHV	Endogenous	CAO, SNA	Billion yen
Official Development Assistance	ODA	Endogenous		Billion yen
Government Revenues, Other	OTGV	Exogenous	=BGV-(TAXV+CSSV+YIGV)+(CGV+IGV+BSSV+SUBV)	
Household Income, Other	OYDV	Exogenous	=YDV-(YWV+YICV+YIEV+BSSV-CSSV-TYPV)	
Government Final Consumption Expenditure, Deflator	PCG	Endogenous	CAO, SNA	1990 = 100
Private Final Consumption Expenditure, Deflator	PCP	Endogenous	CAO, SNA	1990 = 100
Price Earnings Ratio in Tokyo Stock Exchange Market, 1st Section	PER	Endogenous	TSE	
GDP, Deflator	PGDP	Endogenous	CAO, SNA	1990 = 100
Private Business Fixed Investment, Deflator	PIFP	Endogenous	CAO, SNA	1990 = 100
Public Investment, Deflator	PIG	Endogenous	CAO, SNA	1990 = 100
Private Residential Investment, Deflator	PIHP	Endogenous	CAO, SNA	1990 = 100
Changes in Inventories, Deflator	PJ	Endogenous	CAO, SNA	1990 = 100
Land Price Index of City Area, Residential Area, National Average	PLAND	Endogenous	Japan Real Estate Institute	1990 = 100
Imports of Goods and Services, Deflator	PMGS	Endogenous	CAO, SNA	1990 = 100
Imports of Goods and Services in Dollar Base, Deflator	PMGSD	Exogenous	Computed from PMGS and FXS	1990 = 100
Population, Total	POP	Exogenous	MIAC, POP	10,000 persons
Population, over 65 Years Old	POP65	Exogenous	MIAC, POP	10,000 persons
Tokyo Stock Price Index	PSHARE	Endogenous	TSE	100 as on 4th Jan 1968
Factor Income to Abroad	PTRIV	Endogenous	CAO, SNA	Billion yen
Exports of Goods and Services, Deflator	PXGS	Endogenous	CAO, SNA	1990 = 100
CD Interest Rate, 3 Months	RCD	Endogenous	BOJ	%
Official Discount Rate	RDIS	Exogenous	BOJ	%
Yield Rate of Bonds	RGB	Endogenous	BOJ	%
Factor Income from Abroad	RTRIV	Endogenous	CAO, SNA	Billion yen
Accumulated Capital Balance	SBCPV	Endogenous	CAO, SNA	Billion yen
Accumulated Current Balance	SBCV	Endogenous	CAO, SNA	Billion yen
Accumulated Fiscal Balance, General Government	SBGV	Endogenous	CAO, SNA	Billion yen
Subsidies	SUBV	Exogenous	CAO, SNA	Billion yen
Indirect Tax	TAXIV	Endogenous	CAO, SNA	Billion yen
Tax Revenues, Total	TAXV	Endogenous	CAO, SNA	Billion yen

Time Trend	TIME	Exogenous		Calendar year
Private Corporate Tax	TYCV	Endogenous	CAO, SNA	Billion yen
Private Income Tax	TYPV	Endogenous	CAO, SNA	Billion yen
Unemployment Rate	UR	Endogenous	MIAC, LESLFS	%
Producer Price Index in US	USPPI	Exogenous	IMF, IFS	1990 = 100
Bond Yield Rate in US	USRGB	Exogenous	IMF, IFS	%
Per Capita Compensation of Employees	W	Endogenous	= YWV/LW	10,000 yen
Average GDP Deflator of Countries Competing with Japan in the World Market	WPX	Exogenous	IMF, IFS	1990 = 100
Weighted GDP Index of Countries Exported to from Japan	WYVI	Exogenous	IMF, IFS	1990 = 100
Exports of Goods and Services, Real	XGS	Endogenous	CAO, SNA	1990 billion yen
Exports of Goods and Services, Nominal	XGSV	Endogenous	CAO, SNA	Billion yen
Corporate Income before Dividend Payment	YCV	Endogenous	CAO, SNA	Billion yen
Disposable Income, Household	YDV	Endogenous	CAO, SNA	Billion yen
Operation Surplus and Mixed Income	YICV	Endogenous	CAO, SNA	Billion yen
Property Income, Private	YIEV	Endogenous	CAO, SNA	Billion yen
Property Income, General Government	YIGV	Endogenous	CAO, SNA	Billion yen
Property Income, Total	YIV	Endogenous	CAO, SNA	Billion yen
Compensation of Employees	YWV	Endogenous	CAO, SNA	Billion yen

Data sources:

BOJ:	Bank of Japan
CAO, SNA:	Cabinet Office, System of National Accounts
IMF, IFS:	International Monetary Fund, International Financial Statistics
METI:	Ministry of Economy, Trade, and Industry
MHLW:	Ministry of Health, Labor and Welfare
MIAC, LFS:	Ministry of Internal Affairs and Communications, Labor Force Survey
MIAC, POP:	Ministry of Internal Affairs and Communications, Population Census
TSE:	Tokyo Stock Exchange

An Interregional Input-Output Analysis between Aichi Prefecture in Japan and the Coastal Regions of China

Mitsuo Yamada*

Abstract

Based on the available input-output tables for the year 2000, we estimated an interregional I–O table between Japan and China, within which Aichi Prefecture in Japan and the coastal regions in China were the focus. Using this table, we evaluated the degree of interdependence between these regions in 2000. Although the interdependence between Aichi Prefecture and the coastal regions was not so strong, we could observe some differences in the pattern of influences. Furthermore, we examined the impact of the overseas production in the information and communication equipment and transport equipment sectors in the coastal regions. We found that the negative impact, which was brought about by overseas production in the transport equipment sector seeking a new market in China, was lower than that of the information and communication equipment sector shifting its domestic production plants to China.

Keywords: *interregional I–O table; coastal regions of China; Aichi Prefecture, Japan; impact of overseas production*

1. Introduction

After the 1970s, the economies of East Asian countries have grown rapidly; at first Asia's NIEs followed Japan, then ASEAN started to grow, and recently China has joined the group. In China, the growth of the coastal regions is prominent with more than ten percent in GRP growth during the 1990s. The investment inflow from abroad contributes to such high growth.

Table 1 shows that the accumulated inflow of direct investment in China is US$1,096.6 billion on a contract basis and US$572.1 billion on an actually-utilized basis. The actually-utilized investment amounts to US$40-60 billion per year from the year 2000 on, and 70 percent of the investment is concentrated geographically in the coastal region. If we divide the coastal region into two parts, central and other, then the share of the central coastal region in total investment increases from approximately 10 percent in the first half of the 1990s to approximately 40 percent in the latter half. On the other hand, the remainder of the coastal region posted a loss in share from approximately 60 percent to approximately 40 percent between the same periods.

Looking at the countries investing in China (see Figure 2), the four NIE countries and economies, including Hong Kong, invest the largest amount, accounting for half of the regional share. According to the China Statistical Yearbook, the foreign direct investment from Japan amounts to US$3-5 billion for the 2000s, and its share is 7-9 percent. This amount is almost the same as the direct investment from the US or the 15 EU countries. The

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The original version of this paper was prepared when the author was a Visiting Researcher at the Economic Research Center, School of Economics, Nagoya University (April 2006 to September 2006). He would like to express his gratitude to Professor Soemon Takakuwa and Professor Hitoshi Hirakawa for their extraordinary support. This revised paper was supported by a Grant-in Aid for Scientific Research (#17330047) from the Japan Society for the Promotion of Science.

METI Survey on Overseas Business Activities, shows that direct investment from Japan into China amounted to US$1.693 billion in 2000, which is lower than that indicated in the Chinese statistics. The survey shows that sales of overseas firms in China amount to US$33.55 billion for industry as a whole, US$26.48 billion for manufacturing industry, and US$11.05 billion for the electrical machinery industry.

The interdependence among East Asian countries has been strengthened via international trade and capital flow. The trade pattern has been changing from trade between sectors to trade within sectors. Foreign direct investment has been heavily involved in economic development in East Asian countries.

For investing countries, the hollowing out of manufacturing industry and the incubation and promotion of new industries have become important issues. The recent industrial cluster promotion policy in Japan aims to foster the industries that might be competitive in the global market.

Table 1 Direct Investment in China

Unit: million US dollars

	A: Foreign Direct Investment (FDI) (Contracted Base)		B: FDI (Actual Base)	Ratio (B/A)	C: Actual FDI by Region			Regional Shares (C/B) %		
	No. of Projects	Value	Value	%	Central Coast	Other Coast	Rest of China	Central Coast	Other Coast	Rest of China
1979-1983	1,392	7,742	1,802	23.28						
1984	1,856	2,657	1,258	47.35						
1985	3,073	5,932	1,661	28.00						
1986	1,498	2,834	1,874	66.13	207	1,203	331	11.1	64.2	17.7
1987	2,233	3,709	2,314	62.39	284	908	258	12.3	39.3	11.1
1988	5,945	5,297	3,194	60.30	366	1,797	378	11.5	56.3	11.8
1989	5,779	5,600	3,393	60.59	568	2,085	404	16.7	61.4	11.9
1990	7,273	6,596	3,487	52.87	347	2,355	467	9.9	67.5	13.4
1991	12,978	11,977	4,366	36.45	457	3,241	728	10.5	74.2	16.7
1992	48,764	58,124	11,097	19.09	2,197	7,151	1,656	19.8	64.4	14.9
1993	83,437	111,436	27,515	24.69	7,036	14,689	5,617	25.6	53.4	20.4
1994	47,549	82,680	33,767	40.84	7,387	19,557	6,324	21.9	57.9	18.7
1995	37,011	91,282	37,521	41.10	9,341	21,203	6,671	24.9	56.5	17.8
1996	24,556	73,276	41,726	56.94	10,672	23,797	7,411	25.6	57.0	17.8
1997	21,001	51,003	45,257	88.73	11,164	24,311	9,426	24.7	53.7	20.8
1998	19,799	52,102	45,463	87.26	11,551	24,862	8,870	25.4	54.7	19.5
1999	16,918	41,223	40,319	97.81	10,147	23,206	6,582	25.2	57.6	16.3
2000	22,347	62,380	40,715	65.27	11,198	21,644	7,491	27.5	53.2	18.4
2001	26,140	69,195	46,878	67.75	13,418	24,409	8,540	28.6	52.1	18.2
2002	34,171	82,768	52,743	63.72	17,538	24,508	10,426	33.3	46.5	19.8
2003	41,081	115,069	53,505	46.50	21,013	21,549	10,378	39.3	40.3	19.4
2004	43,664	153,479	60,630	39.50						
1979-2004	508,941	1,096,609	562,105	51.26						

This table was compiled using data from the *China Statistical Yearbook*.
See Table 5 for definition of regions.

Table 2 Direct Investment in China by Country

Unit: million US dollars

	Total	Japan	NIEs 4	ASEAN 4	EU 15	USA	Other
1986	2,244	263	1,342	11	176	326	125
1987	2,314	220	1,620	15	53	263	143
1988	3,194	515	2,123	11	157	236	152
1989	3,393	356	2,162	16	188	284	387
1990	3,487	503	1,964	10	151	456	403
1991	4,667	610	3,109	30	444	331	144
1992	11,292	748	9,006	146	268	519	605
1993	27,771	1,361	21,457	514	690	2,068	1,680
1994	33,946	2,086	25,120	692	1,544	2,491	2,013
1995	37,806	3,212	26,258	765	2,152	3,084	2,335
1996	42,135	3,692	28,085	937	2,743	3,444	3,234
1997	45,257	4,326	28,670	811	4,171	3,239	4,039
1998	45,463	3,400	26,631	794	3,979	3,898	6,760
1999	40,319	2,973	22,879	632	4,479	4,216	5,139
2000	40,715	2,916	21,458	665	4,479	4,384	6,813
2001	46,878	4,348	23,993	826	4,183	4,433	9,094
2002	52,743	4,190	26,890	863	3,711	5,424	11,665
2003	53,505	5,054	27,624	795	3,930	4,199	11,903
2004	60,630	5,452	30,372	901	4,239	3,941	15,725
Shares (%)	Total	Japan	NIEs 4	ASEAN 4	EU 15	USA	Other
1986	100.00	11.74	59.83	0.49	7.83	14.54	5.58
1987	100.00	9.50	70.02	0.66	2.28	11.36	6.19
1988	100.00	16.11	66.48	0.36	4.92	7.39	4.75
1989	100.00	10.50	63.72	0.47	5.53	8.38	11.40
1990	100.00	14.44	56.32	0.29	4.32	13.08	11.56
1991	100.00	13.06	66.63	0.64	9.51	7.09	3.08
1992	100.00	6.63	79.76	1.29	2.37	4.60	5.36
1993	100.00	4.90	77.27	1.85	2.48	7.45	6.05
1994	100.00	6.15	74.00	2.04	4.55	7.34	5.93
1995	100.00	8.50	69.46	2.02	5.69	8.16	6.18
1996	100.00	8.76	66.65	2.22	6.51	8.17	7.67
1997	100.00	9.56	63.35	1.79	9.22	7.16	8.92
1998	100.00	7.48	58.58	1.75	8.75	8.58	14.87
1999	100.00	7.37	56.75	1.57	11.11	10.46	12.75
2000	100.00	7.16	52.70	1.63	11.00	10.77	16.73
2001	100.00	9.28	51.18	1.76	8.92	9.46	19.40
2002	100.00	7.94	50.98	1.64	7.04	10.28	22.12
2003	100.00	9.45	51.63	1.49	7.35	7.85	22.25
2004	100.00	8.99	50.09	1.49	6.99	6.50	25.94

This table was compiled using data from the China Statistical Yearbook.

Table 3 The Overseas Activities of Japanese Firms (2000)

Number of Overseas Affiliated Companies	Total	Asia	China		
				Mainland	Hong Kong
Total	14,991	7,244	2,530	1,712	818
Manufacturing, Total	7,464	4,487	1,540	1,263	277
Food products	394	223	108	92	16
Textile products	525	415	255	224	31
Paper and pulp	119	59	22	21	1
Chemicals	1,055	634	175	142	33
Petroleum and coal	34	20	7	x	-
Iron and steel	266	174	56	52	4
Nonferrous metals	195	127	39	32	7
General machinery	764	391	130	105	25
Electrical machinery	1,827	1,126	382	283	99
Transport equipment	1,036	525	108	106	2
Precision instruments	269	133	58	32	26
Miscellaneous manufactured articles	980	650	200	167	33
Non-manufacturing, total	7,527	2,757	990	449	541
Agriculture, forestry, and fishery	125	37	14	13	1
Mining	160	19	3	2	1
Construction	362	225	34	13	21
Wholesale and retail trade	3,645	1,397	534	204	330
Services	1,443	474	207	125	82
Other	1,792	605	198	92	106

Investment million US dollars	Total	Asia	China		
				Mainland	Hong Kong
Total	30,503	9,855	2,460	1,693	767
Manufacturing, Total	21,870	8,847	2,293	1,620	673
Food products	455	116	26	24	2
Textile products	532	385	141	117	24
Paper and pulp	225	46	12	x	x
Chemicals	2,230	634	101	97	4
Petroleum and coal	4	3	1	1	-
Iron and steel	1,640	326	227	15	212
Nonferrous metals	489	281	45	32	13
General machinery	717	274	83	57	26
Electrical machinery	6,878	4,428	1,035	706	329
Transport equipment	5,989	1,120	280	x	x
Precision instruments	348	231	98	49	49
Miscellaneous manufactured articles	2,363	1,004	216	203	13
Non-manufacturing, total	8,633	1,009	167	73	94
Agriculture, forestry, and fishery	84	13	8	x	x
Mining	221	3	-	-	-
Construction	310	11	0	x	x
Wholesale and retail trade	2,297	361	92	27	65
Services	3,127	211	25	23	2
Other	2,595	410	42	15	27

Sales million US dollars	Total	Asia	China		
				Mainland	Hong Kong
Total	1,197,160	337,543	98,635	33,551	65,085
Manufacturing, Total	521,668	184,637	47,125	26,479	20,646
Food products	13,260	3,679	1,026	783	244
Textile products	10,913	8,095	3,229	1,543	1,686
Paper and pulp	5,137	859	195	x	x
Chemicals	46,481	15,353	1,801	1,300	501
Petroleum and coal	1,753	1,232	26	26	-
Iron and steel	18,881	5,623	1,062	955	107
Nonferrous metals	8,292	4,115	971	667	304
General machinery	31,601	9,190	4,316	2,238	2,078
Electrical machinery	181,922	87,434	24,387	11,050	13,336
Transport equipment	154,204	32,444	4,693	x	x
Precision instruments	1,147	5,353	2,700	1,097	1,604
Miscellaneous manufactured articles	37,778	11,259	2,720	1,945	774
Non-manufacturing, total	675,492	152,905	51,510	7,072	44,438
Agriculture, forestry, and fishery	1,160	375	x	x	x
Mining	13,014	6,192	x	x	x
Construction	6,499	2,351	197	54	143
Wholesale and retail trade	555,628	132,350	48,544	6,068	42,476
Services	69,241	6,323	1,271	470	801
Other	29,950	5,314	1,291	334	956

Data Source: *The 31st Survey of Overseas Business Activities*, METI, Japan

The Asian International Input-Output Table is useful as a framework for investigation of the interdependence of East Asian countries through industrial and trade transactions. The estimation and many applications of the Asian International Input-Output Table by the Institute of Developing Economies (IDE) show that it is an important tool for such research.

On the other hand, the importance of regional studies in East Asian countries is increasing, as, for example, we know that China is not uniform geographically. Looking at the Japanese economy, there is a difference in regional economic structure, and we should understand the likely future industrial structure in light of such regional characteristics.

For regional input-output analysis in China, Shuntaro Shishido, Kazumi Kawamura, and Fan Wen Hui (1996) made an input-output table for Heilongjiang Province, China; Zaizhe Wang (2002) used the input-output table for Shanghai; Ichimura and Huijiong Wang (2004) made the 1987 interregional input-output table for China, which had 7 regions with 9 sectors; while the IDE (2003) constructed the 2000 interregional input-output table for China, which had 8 regions with 30 sectors.

There are two types of international input-output tables connecting Japan and China; the Japan-China tables and the Asia tables, which link ten countries including Japan and China. The IDE made prolonged effort to compile these tables. The tables provide very important statistics for investigating the interdependence between Japan and China. There is, however, no table connecting the regions within these two countries.

Thus we focused our attention on the interrelations between Japan and China in terms of region. We focused on Aichi Prefecture in Japan, and the coastal regions (Central and Other) in China. Manufacturing industries in Aichi Prefecture are relatively strong in market competition. The coastal regions, on the other hand, are leading rapid economic growth in China, using foreign investment. We developed a Japan-China interregional input-output table, in which five regions appear; two regions in Japan and three regions in China. Then we undertook simulation analysis on the interdependence among them.

2. Methodology and Data

To capture the interdependence between Aichi Prefecture in Japan and the two coastal regions in China, we undertook the development of an interregional input-output table between them. Here the Yangtze Delta area is defined as the Central Coast area including Shanghai City, Jiangsu Province, and Zhejiang Province.

There are two ways to approach such an input-output table. One is to divide geographically a country-based Japan-China input-output table into the corresponding regions by some method to maintain consistency between the two tables. The other contrary method is to combine regional tables in each country to create an international table. In the latter case, we need information on international trade between these regions.

The Input-output tables available to us were the Input-Output Table of Japan and regional tables. METI regional input-output tables[1] were also available for nine regions in Japan. There were additionally input-output tables for each prefecture in Japan. For China, many cities and provinces have their own input-output tables. The tables published,

[1] The Chubu region input-output table is one of the METI regional tables. The Chubu region consists of five prefectures: Aichi, Gifu, Mie, Toyama, and Ishikawa. There is also an input-output table for the Tokai region, which includes three prefectures: Aichi, Gifu, and Mie. The so-called "Greater Nagoya" region might be taken to correspond to the Tokai region which includes Aichi Prefecture.

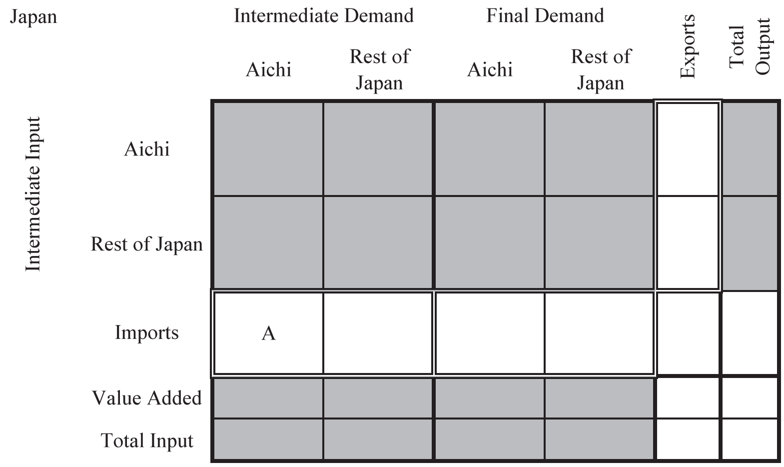
however, are usually consolidated into major sectors, and detailed tables are often not available. Fortunately, the IDE provided a Chinese interregional input-output table for the year 2000, which was available to us. This table covered eight regions, one of which was the central coastal region, the Yangtze Delta area.

In this study, we applied the latter method, taking into consideration the availability of data and the ease of the method. First we drew up a regional input-output table for each country; a two-region interregional I-O table for 2000 for Japan, Aichi Prefecture and the rest of Japan, and a three-region interregional I-O table 2000 for China, the Central Coast, Other Coast, and the rest of China. We thus obtained a interregional I-O tables for five regions, which we combined into one table.

2.1 The Two-Region Interregional I-O Table for 2000 for Japan

Using two input-output tables for Japan and Aichi Prefecture, respectively, we subtracted the value of transactions in Japan from those in Aichi Prefecture to obtain an input-output table for the other regions of Japan. We know that the internal exports to other regions from Aichi Prefecture are equal to the internal imports of the other regions from Aichi Prefecture and the same holds for the respective imports into and exports to Aichi Prefecture. Thus, using the average interregional transaction ratio of each sector, we were able to estimate a two-region interregional input-output table for Japan, Aichi Prefecture and the rest of Japan. We arranged this table as non-competitive in terms of international imports. Then we converted the values of the table from yen to US dollars using the exchange rate for that year. Figure 1 illustrates the table's structure.

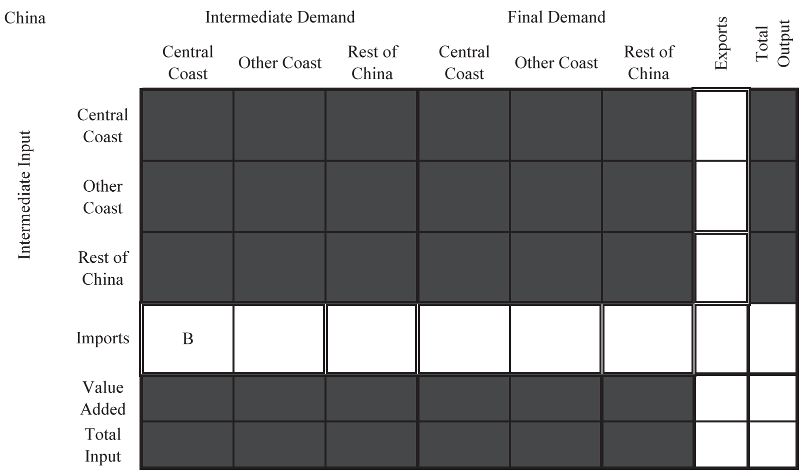
Figure 1 Aichi Prefecture-Rest of Japan Interregional Input-Output Table



2.2 The Three-Region Interregional I-O Table for 2000 for China

For China, we used the interregional I-O table for 2000. This table contains eight Chinese regions, and is a table competitive in terms of international imports. Using this table, we consolidated these regions into three regions; Central Coast, Other Coast, and the rest of China. We changed the table from a competitive one in terms of international imports to a non-competitive one. Additionally, we converted the values in this table from yuan to US dollars, using the exchange rate for that year. This table's structure is shown in Figure 2.

Figure 2 Three-Region Interregional Input-Output Table



2.3 The Five-Region Interregional I-O Table for Japan and China

To integrate these two interregional I-O tables into one, we had to separate the import values of each from the total import value. Here we used the information from the Asian International I-O table of the IDE. The IDE table contains the import values, intermediate goods and final products for Japan from China and those for China from Japan. Those values are evaluated in producer price terms, because the imports of these countries are expressed as endogenous sectors. We then calculated the respective import shares of China in Japan and those of Japan in China. Using these shares, we estimated the import values, in producer price terms, for each Japan region from China, and those for each Chinese region from Japan.

The next step was to separate the import values for Aichi Prefecture from China into those from each of China's regions. Unfortunately, we had little statistical information for this procedure. Therefore we assumed that the imports from each region depended on the export capacity of each corresponding region, and we estimated the latter using the export share of each region in China. For the other regions in Japan and China we applied the same assumption to obtain the import values from each region. Figure 3 shows the procedure.

Finally, we combined both of the I-O tables, for Japan and China, into one table, namely the Japan-China five-region interregional I-O table as shown in Figure 4.

Figure 3 Regional Breakdown of Imported Intermediate Input

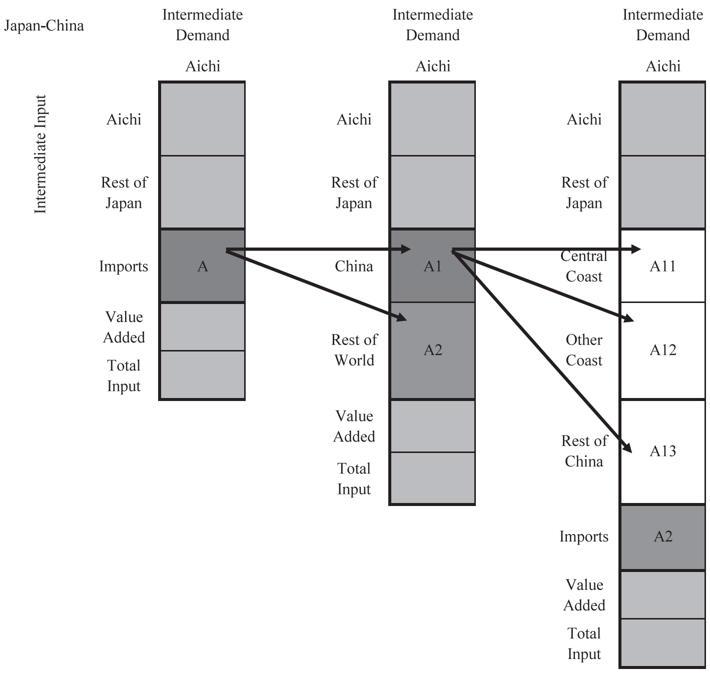
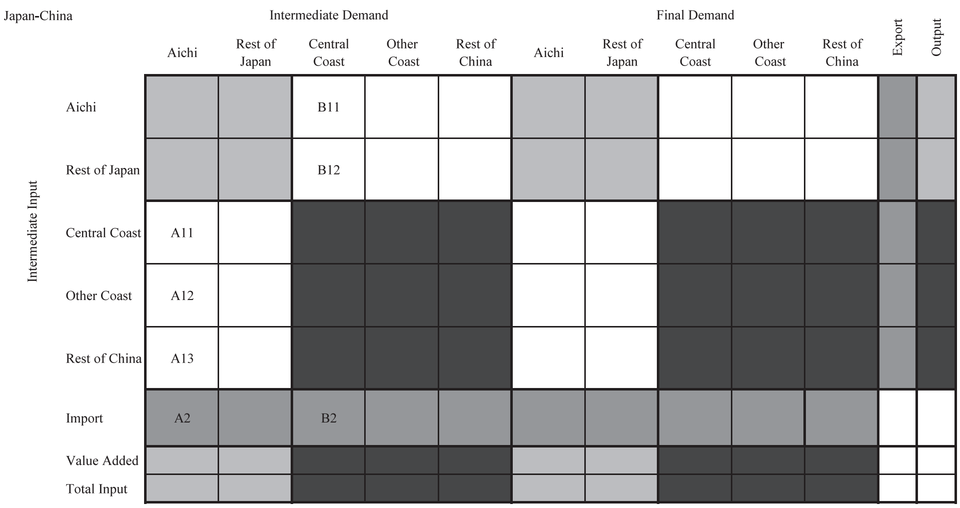


Figure 4 Japan-China Interregional Input-Output Table



3. Estimation of I-O Tables

The correspondences in classification between the I-O tables are shown in Table 4. The IDE Chinese Interregional Input-Output Table 2000 has 30 sectors for each region, while its Asian International Input-Output Table for 2000 has 76 sectors for each country. The Japan input-output table for 2000 by the Ministry of Internal Affairs and Communications and others is more detailed than the above tables and we used their table which has a 104-sector classification. We define our 26 sectors here, comparing them with the classifications for the above three I-O tables.

Table 5 shows the regional definition used in our analysis, with three regions,[2] in comparison with the IDE Chinese Interregional Input-Output Table for 2000, in which eight regions appear.

We compiled a five-region 26-sector interregional input-output table for Japan and China. Table 6, however, shows a five-region one-sector table, which is a composite of all the sectors. From this table, we find that the output for Aichi Prefecture is US$0.684 trillion, and US$8.213 trillion for the rest of Japan, as against US$0.559 trillion for the Central Coast region, US$0.817 trillion for the Other Coast region, and US$1.038 trillion for the rest of China.

Table 4 Sector Classification

Sector	China I-O Table (30 Sectors)	Japan I-O Table (104 Sectors)	Asian I-O Table (76 Sectors)
1 Agriculture, forestry, and fisheries	1	001 002 003 004 005	001 002 003 004 005 006 007
2 Crude petroleum and natural gas products	3	009	008
3 Metal ore mining	4	006	009 010
4 Coal mining and processing and others	2 5	007 008	011
5 Food products and tobacco	6	010 011 012 013	012 013 014 015 016 017
6 Textile products	7	014	018 019 020
7 Articles of apparel, leather and furs	8	015	021 022 023
8 Sawmill products and furniture	9	016 017	024 025 026
9 Paper and pulp	10	018 019 020	027 028
10 Petroleum processing and coking	11	029 030	034
11 Chemicals	12	021 022 023 024 025 026 027 028	029 030 031 032 033
12 Nonmetal mineral products	13	034 035 036 037	038 039 040
13 Primary metals	14	038 039 040 041 042 043	041 042
14 Metal products	15	045	043
15 General machinery	16	046 047 048 049	044 045 046 047
16 Electrical machinery	18	050 056 057	048 053 054
17 Information and communication equipment	19	051 052 053 054 055	049 050 051 052
18 Transport equipment	17 21	058 059 060 061	055 056 057 058
19 Precision instruments	20	062	059
20 Other manufactured articles	22 23	031 032 033 063 064 103	035 036 037 060
21 Electricity, steam and hot water, and gas	24 25	069 070	061
22 Water production and supply	26	071 072	062
23 Construction	27	065 066 067 068	063 064
24 Wholesale and retail trade	29	073	066
25 Transport and warehousing	28	078 079 080 081 082 083 084 085	065
26 Services	30	074 075 076 077 086 087 088 089 090 091 092 093 094 095 096 097 098 099 100 101 102 104	067 068 069 070 071 072 073 074 076 075

[2] Another three-region definition, which is also shown within Table 5, is sometimes used–the Eastern Region, the Central Region, and the Western Region. This definition was first used in the Seventh Five-Year Plan of the Chinese government as the "Three Major Economic Regions."

Table 5 Definition of Regions in China

		Central Coast	Other Coast	Rest of China	Eastern	Central	Western
Northeast	Heilongjiang			■		■	
	Jilin			■		■	
	Liaoning			■	■		
North Municipalities	Beijing		■		■		
	Tianjin		■		■		
North Coast	Hebei		■		■		
	Shandong		■		■		
Central Coast	Jiangsu	■			■		
	Shanghai	■			■		
	Zhejiang	■			■		
South Coast	Fujian		■		■		
	Guangdong		■		■		
	Hainan		■		■		
Central	Shanxi			■		■	
	Henan			■		■	
	Anhui			■		■	
	Hubei			■		■	
	Hunan			■		■	
	Jiangxi			■		■	
Northwest	Inner Mongolia			■		■	
	Shaanxi			■			■
	Ningxia			■			■
	Gansu			■			■
	Qinghai			■			■
	Xinjiang			■			■
Southwest	Sichuan			■			■
	Chongqing			■			■
	Yunnan			■			■
	Guizhou			■			■
	Guangxi			■	■		
	Tibet			■			■

Taiwan, Hong Kong, and Macau are not included.

Table 6 Japan-China Interregional Input-Output Table (Five-Region One-Sector)

Unit: US$ million	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China	Intermediate Demand, Total	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China	Export	Statistical Discrepancy	Total Output
Aichi	234,871	93,659	454	768	227	329,979	216,248	66,316	180	293	117	71,245	0	684,378
Rest of Japan	100,713	3,332,415	4,921	9,508	1,645	3,449,202	53,004	4,266,881	1,364	2,535	691	439,472	0	8,213,149
Central Coast	760	5,581	294,212	23,487	21,848	345,887	456	6,037	140,986	6,047	10,305	44,525	4,481	558,726
Other Coast	1,407	12,533	32,319	400,210	41,374	487,843	957	12,906	5,541	234,334	19,847	86,048	-30,035	817,441
Rest of China	459	3,840	31,807	40,512	558,703	635,321	190	2,804	4,510	8,528	412,935	20,965	-47,375	1,037,878
Rest of World	21,711	269,295	28,640	61,526	12,068	393,241	7,188	156,438	8,216	16,948	4,994	0	0	587,026
Intermediate Input, Total	359,921	3,717,323	392,353	536,011	635,865	5,641,472	278,043	4,511,382	160,798	268,686	448,889	662,255	-72,929	11,898,597
Value Added	324,457	4,495,826	166,373	281,430	402,013	5,670,099								
Total Input	684,378	8,213,149	558,726	817,441	1,037,878	11,311,571								

	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China	Intermediate Demand, Total	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China	Export	Statistical Discrepancy	Total Output
Aichi	0.3432	0.0114	0.0008	0.0009	0.0002	0.0292	0.778	0.015	0.001	0.001	0.000	0.108	0.000	0.058
Rest of Japan	0.1472	0.4057	0.0088	0.0116	0.0016	0.3049	0.191	0.946	0.008	0.009	0.002	0.664	0.000	0.690
Central Coast	0.0011	0.0007	0.5266	0.0287	0.0211	0.0306	0.002	0.001	0.877	0.023	0.023	0.067	-0.061	0.047
Other Coast	0.0021	0.0015	0.0578	0.4896	0.0399	0.0431	0.003	0.003	0.034	0.872	0.044	0.130	0.412	0.069
Rest of China	0.0007	0.0005	0.0569	0.0496	0.5383	0.0562	0.001	0.001	0.028	0.032	0.920	0.032	0.650	0.087
Rest of World	0.0317	0.0328	0.0513	0.0753	0.0116	0.0348	0.026	0.035	0.051	0.063	0.011	0.000	0.000	0.049
Intermediate Input, Total	0.5259	0.4526	0.7022	0.6557	0.6127	0.4987	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Value Added	0.4741	0.5474	0.2978	0.3443	0.3873	0.5013								
Total Input	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000								

Figure 5 shows the output and industrial structure of each region. The total output of Japan is approximately 4 times larger than that of China. The economic scale of Aichi Prefecture in Japan is almost the same as those of the Central Coast region and the Other Coast region in China. Figure 6 shows the industrial structure of each region in a bar graph. The output of the service sector is largest in Aichi Prefecture and the transport equipment sector has a large manufacturing output. In China, however, the service sector output is not as large as in Japan. Food products, textile products, apparel, chemicals, general machinery, electrical machinery, and precision instruments show a larger output. As would be expected agricultural output is large.

The comparative advantage in regional output in Japan and China is shown in Table 7. Aichi Prefecture has the edge in transport equipment and textile products, compared to the other regions of Japan. Nonmetal mineral products, primary metals, metal products, general machinery, and electrical machinery follow behind them. The Central Coast region has its greatest edge in textile products, followed by sectors like apparel, general machinery, electrical machinery, information and communication equipment, and precision instruments. The Other Coast region, on the other hand, has the highest comparative advantage in information and communication equipment, followed by apparel, paper and pulp, electrical machinery, and precision instruments.

Figures 7a, 7b, and 7c show the regional shares of sale transactions in each sector for Aichi Prefecture, the Central Coast, and the Other Coast region, respectively. Direct demand from China to Japan is not great in any of the sectors, although a small share is observed in sectors like textile products, chemicals, primary metals, general machinery, and electrical machinery. On the other hand, the direct demand from Japan to the two coastal regions is large in apparel, sawmill products and furniture (wood and wood products), electrical machinery, information and communication equipment, precision instruments, and miscellaneous manufactured articles. This is additionally so in the oil and gas sector for the Other Coast region. The demand from Aichi Prefecture, however, to the two coast regions is not very great.

Figure 5 Regional Output

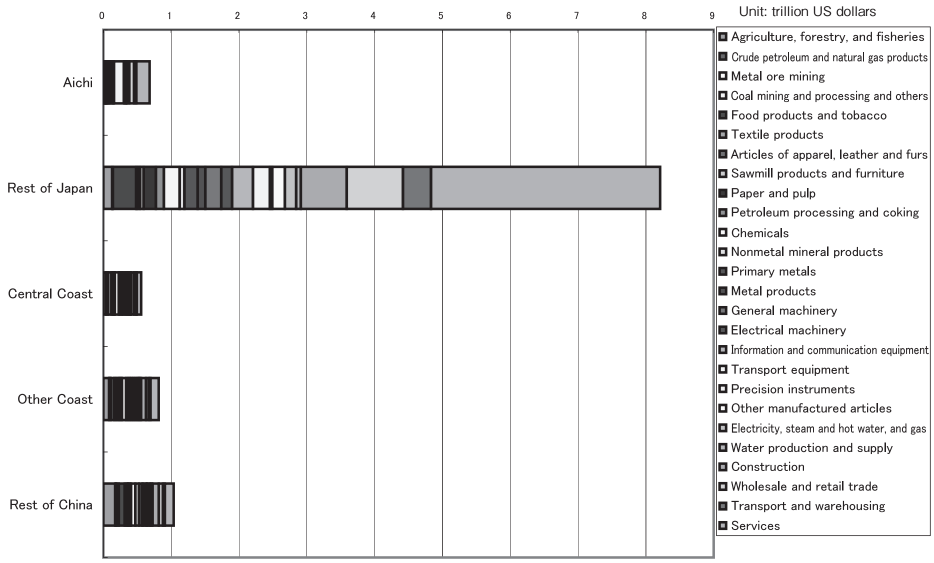


Figure 6 Comparison of Industrial Structure: Aichi Prefecture and the Two Coastal Regions

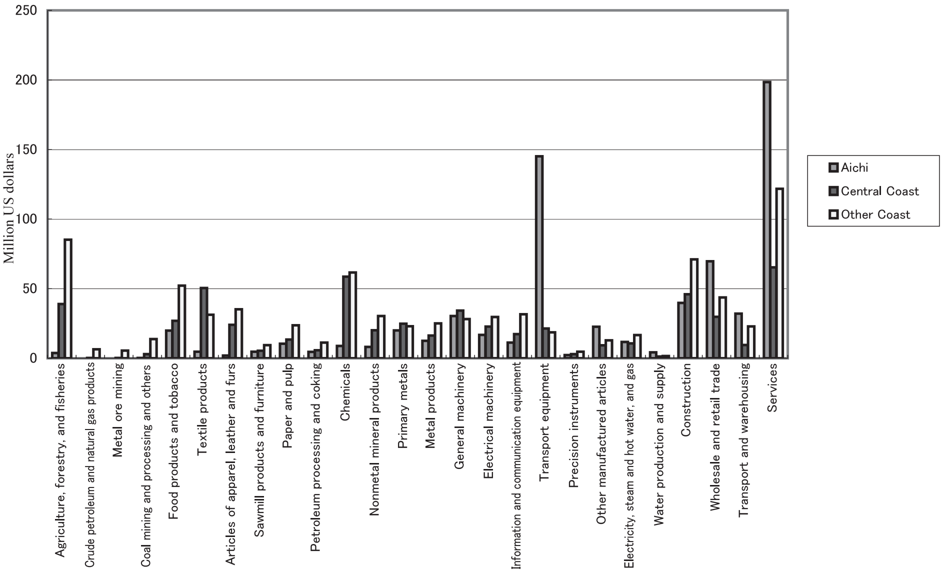


Table 7 Comparative Advantage of Each Region

	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China
1 Agriculture, forestry, and fisheries	0.370	1.053	0.564	0.844	1.358
2 Crude petroleum and natural gas products	0.000	1.083	0.063	0.972	1.527
3 Metal ore mining	0.000	1.083	0.074	1.125	1.400
4 Coal mining and processing and others	0.293	1.059	0.268	0.841	1.520
5 Food products and tobacco	0.717	1.024	0.697	0.925	1.222
6 Textile products	2.320	0.890	1.945	0.825	0.629
7 Articles of apparel, leather and furs	0.630	1.031	1.412	1.415	0.452
8 Sawmill products and furniture	1.063	0.995	0.862	1.024	1.056
9 Paper and pulp	0.710	1.024	1.088	1.312	0.707
10 Petroleum processing and coking	0.502	1.041	0.666	0.888	1.268
11 Chemicals	0.473	1.044	1.379	0.990	0.804
12 Nonmetal mineral products	1.368	0.969	0.815	0.844	1.222
13 Primary metals	1.204	0.983	1.141	0.724	1.141
14 Metal products	1.301	0.975	1.168	1.233	0.726
15 General machinery	1.488	0.959	1.488	0.836	0.867
16 Electrical machinery	1.239	0.980	1.461	1.306	0.510
17 Information and communication equipment	0.460	1.045	1.269	1.578	0.400
18 Transport equipment	4.766	0.686	1.265	0.753	1.052
19 Precision instruments	0.810	1.016	1.272	1.374	0.559
20 Other manufactured articles	1.413	0.966	1.177	1.104	0.823
21 Electricity, steam and hot water, and gas	0.851	1.012	0.942	1.007	1.025
22 Water production and supply	0.770	1.019	1.167	1.024	0.891
23 Construction	0.720	1.023	0.947	0.999	1.030
24 Wholesale and retail trade	1.006	0.999	0.965	0.966	1.045
25 Transport and warehousing	0.939	1.005	0.671	1.107	1.093
26 Services	0.721	1.023	0.887	1.131	0.957

Figure 7a Regional Structure of Sectoral Demand, Aichi Prefecture

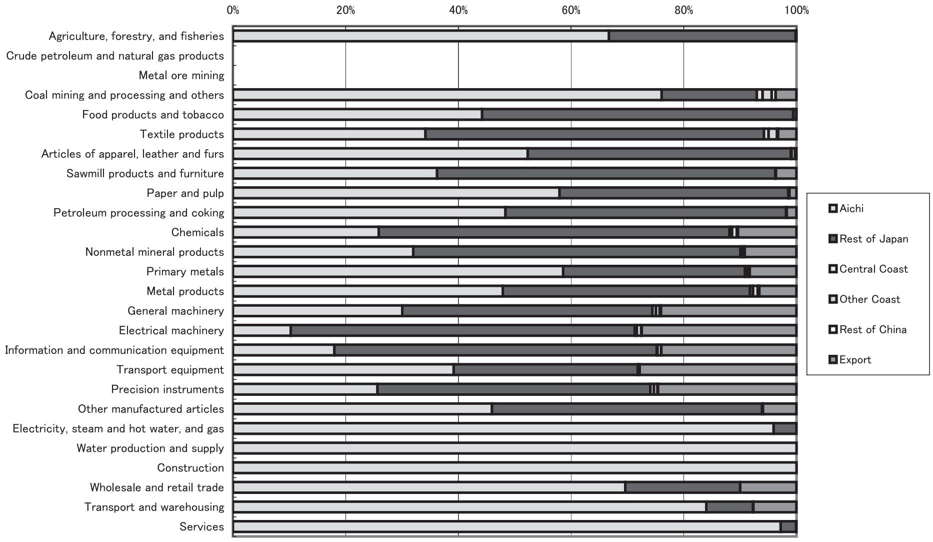


Figure 7b Regional Structure of Sectoral Demand, Central Coast

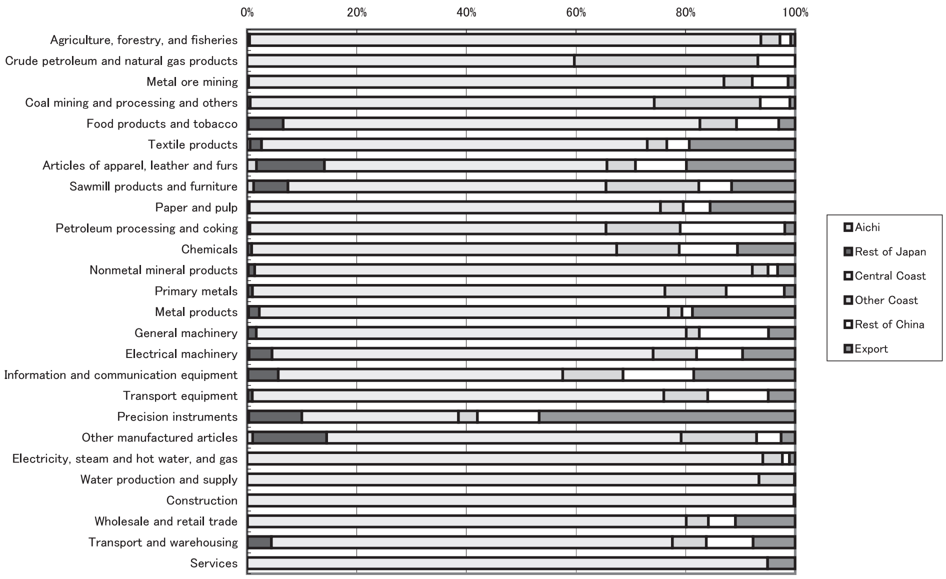


Figure 7c Regional Structure of Sectoral Demand, Other Coast

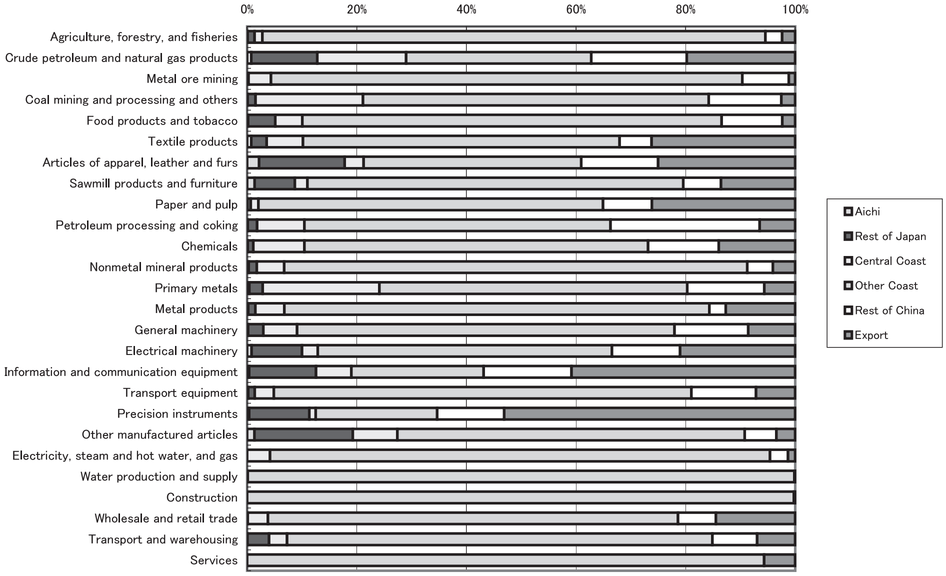


Figure 8 shows the international trade between Aichi Prefecture and each Chinese region by sector. Negative values show imports into Aichi Prefecture from China, and positive values show exports from Aichi Prefecture to China. Aichi Prefecture export products include transport equipment, electrical machinery, primary metals, metal products, chemicals, and textile products to China. In these sectors, Aichi Prefecture has the relative advantage. On the other hand, China's exports to Aichi Prefecture include apparel, textile products, food, primary metals, electrical machinery, information and communication equipment, and miscellaneous manufactured articles. Aichi Prefecture's exports to the Central Coast region are relatively large in terms of general machinery and transport equipment, and the imports of apparel and primary metals are relatively the most important.

Figure 9 shows the regional impact of a one-unit increase in the final products of each sector in Aichi Prefecture, which are deduced via a row vector of a Leontief-inverse matrix. Because the impact on the rest of Japan is much stronger than on China, they are shown on different scales; the left-hand axis for the rest of Japan and the right-hand axis for the regions in China. Figure10a presents the information from Figure 9 for China only in a separate bar graph. The impact on China appears strong in sectors in which imports from Aichi Prefecture are larger. Textile products and apparel are strongly affected, and the effects on the Central Coast region and the Other Coast region are large. With respect to primary metals, however, the effect on the rest of China is greater than or equal to those on the two coastal regions.

Figure 10b shows the impact on Aichi Prefecture of each region's increase in demand for final products. From this figure the impact of the two coastal regions on Aichi Prefecture in any sector is stronger than that of the rest of China; the impact of transport equipment is the strongest, followed by primary metals, metal products, general machinery, electrical machinery, information and communication equipment, and precision instruments. Textile products and apparel also have relatively large impacts.

Figure 8 International Trade between Aichi Prefecture and Each Chinese Region

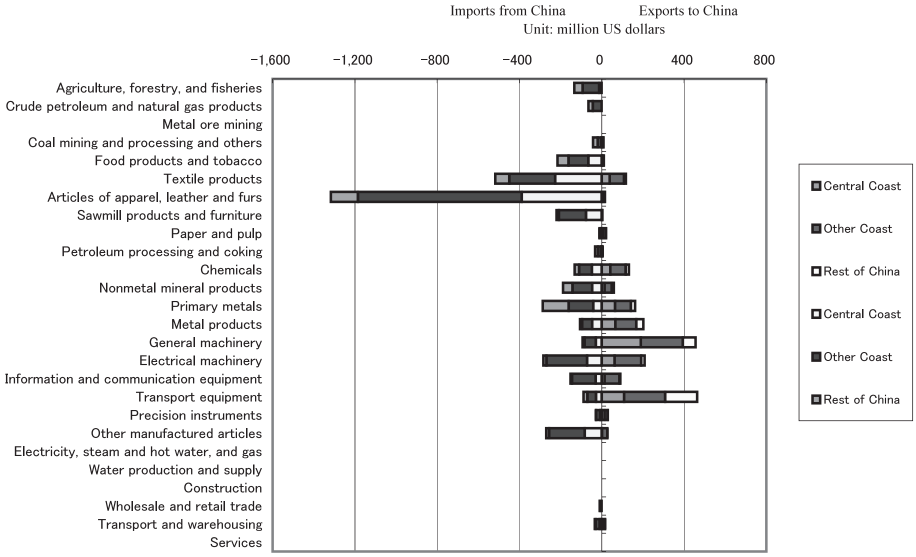


Figure 9 Regional Induced Effects of Each Sectoral Final Demand on Aichi Prefecture

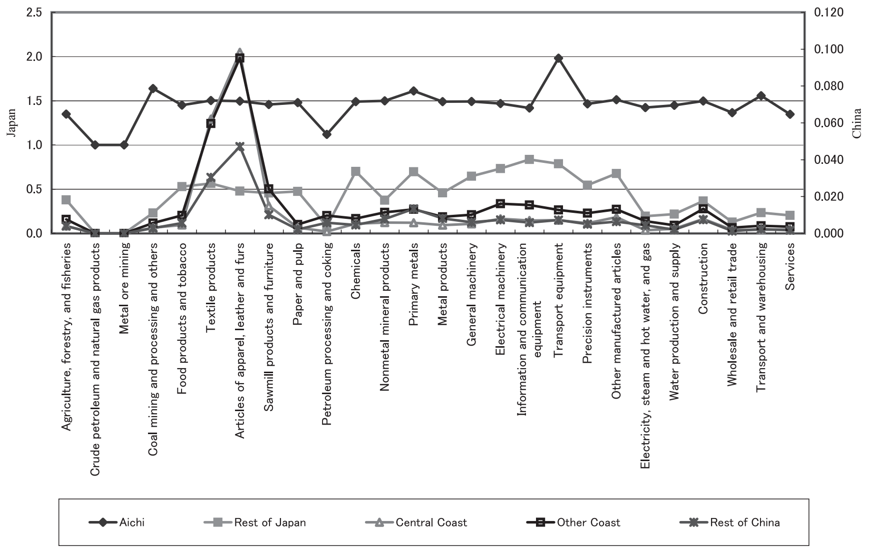


Figure 10a Effects Induced on Chinese Regions by Each Sectoral Final Demand in Aichi Prefecture

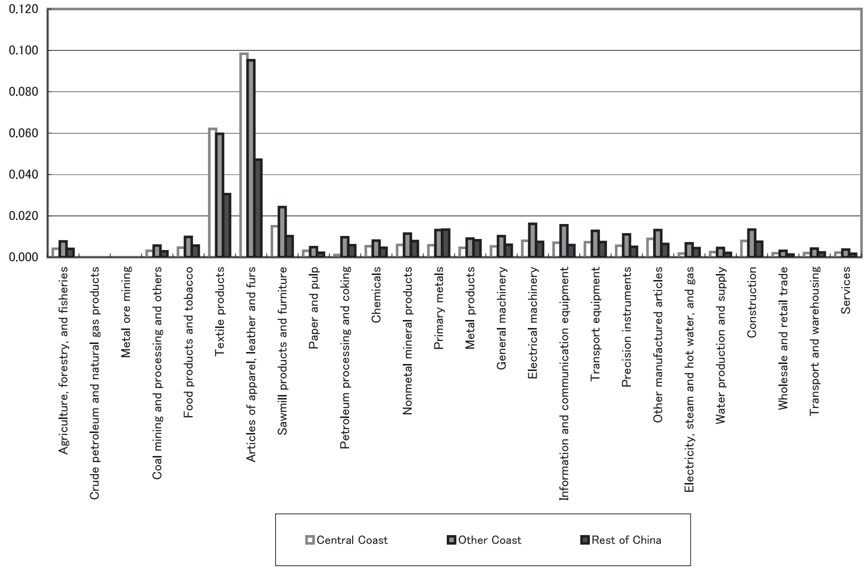


Figure 10b Effects Induced on Aichi Prefecture by Each Sectoral Final Demand in Chinese Regions

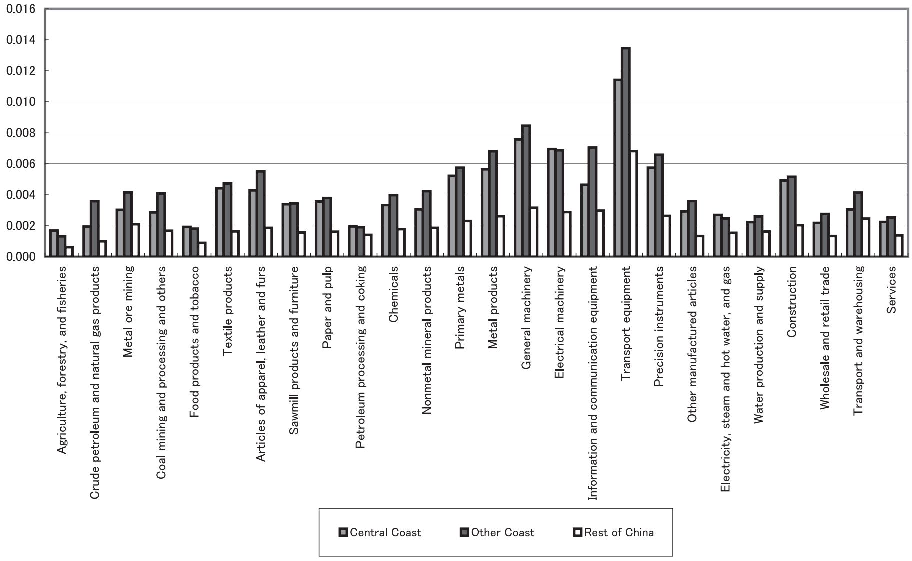


Table 8 shows the regional contributions in terms of value added and imports induced by a one-unit increase in each final demand. In all cases in Aichi Prefecture or the rest of Japan, the contribution of the regions in China is very small or almost negligible. In the case of textile products and apparel, the contribution of China as a whole is approximately 5-7 percent, and less than 1 percent for the other sectors in Aichi Prefecture. On the other hand, the contribution of Japan as a whole to each region of China is 3-6 percent in the machinery sectors, and that of Aichi Prefecture is very small in terms of the contribution therein.

Table 8 Regional Contribution to a One-Unit Increase in Each Final Demand, Measured by Induced Imports and Value Added

		Import	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China	Total
Aichi	1 Agriculture, forestry, and fisheries	0.069	0.744	0.181	0.001	0.003	0.002	1.000
	2 Crude petroleum and natural gas products	1.000	0.000	0.000	0.000	0.000	0.000	1.000
	3 Metal ore mining	1.000	0.000	0.000	0.000	0.000	0.000	1.000
	4 Coal mining and processing and others	0.062	0.822	0.112	0.001	0.002	0.001	1.000
	5 Food products and tobacco	0.085	0.648	0.259	0.001	0.004	0.002	1.000
	6 Textile products	0.105	0.603	0.246	0.016	0.019	0.011	1.000
	7 Articles of apparel, leather and furs	0.099	0.621	0.209	0.025	0.030	0.016	1.000
	8 Sawmill products and furniture	0.151	0.624	0.209	0.004	0.008	0.004	1.000
	9 Paper and pulp	0.049	0.724	0.224	0.001	0.002	0.001	1.000
	10 Petroleum processing and coking	0.478	0.476	0.038	0.000	0.005	0.003	1.000
	11 Chemicals	0.113	0.581	0.301	0.002	0.003	0.002	1.000
	12 Nonmetal mineral products	0.086	0.729	0.177	0.002	0.004	0.003	1.000
	13 Primary metals	0.148	0.569	0.273	0.002	0.004	0.004	1.000
	14 Metal products	0.086	0.719	0.188	0.001	0.003	0.003	1.000
	15 General machinery	0.082	0.634	0.277	0.001	0.003	0.002	1.000
	16 Electrical machinery	0.103	0.579	0.309	0.002	0.005	0.002	1.000
	17 Information and communication equipment	0.115	0.525	0.352	0.002	0.004	0.002	1.000
	18 Transport equipment	0.108	0.581	0.303	0.002	0.004	0.002	1.000
	19 Precision instruments	0.083	0.669	0.242	0.002	0.003	0.002	1.000
	20 Other manufactured articles	0.109	0.593	0.289	0.003	0.004	0.002	1.000
	21 Electricity, steam and hot water, and gas	0.210	0.690	0.095	0.001	0.003	0.002	1.000
	22 Water production and supply	0.050	0.844	0.103	0.001	0.002	0.001	1.000
	23 Construction	0.080	0.742	0.169	0.002	0.004	0.003	1.000
	24 Wholesale and retail trade	0.021	0.911	0.065	0.001	0.001	0.000	1.000
	25 Transport and warehousing	0.081	0.801	0.114	0.001	0.001	0.001	1.000
	26 Services	0.030	0.872	0.096	0.001	0.001	0.001	1.000
Rest of Japan	1 Agriculture, forestry, and fisheries	0.064	0.010	0.921	0.001	0.002	0.002	1.000
	2 Crude petroleum and natural gas products	0.029	0.004	0.966	0.000	0.001	0.000	1.000
	3 Metal ore mining	0.059	0.006	0.933	0.000	0.001	0.001	1.000
	4 Coal mining and processing and others	0.068	0.008	0.921	0.001	0.001	0.001	1.000
	5 Food products and tobacco	0.081	0.013	0.899	0.001	0.004	0.002	1.000
	6 Textile products	0.085	0.029	0.864	0.008	0.010	0.005	1.000
	7 Articles of apparel, leather and furs	0.071	0.034	0.864	0.010	0.013	0.007	1.000
	8 Sawmill products and furniture	0.090	0.017	0.886	0.002	0.004	0.002	1.000
	9 Paper and pulp	0.055	0.013	0.929	0.001	0.002	0.001	1.000
	10 Petroleum processing and coking	0.453	0.002	0.537	0.000	0.005	0.003	1.000
	11 Chemicals	0.108	0.014	0.873	0.001	0.002	0.001	1.000
	12 Nonmetal mineral products	0.084	0.013	0.897	0.001	0.003	0.002	1.000
	13 Primary metals	0.168	0.020	0.804	0.001	0.003	0.003	1.000
	14 Metal products	0.083	0.015	0.896	0.001	0.002	0.002	1.000
	15 General machinery	0.092	0.024	0.877	0.001	0.003	0.002	1.000
	16 Electrical machinery	0.108	0.022	0.862	0.002	0.005	0.002	1.000
	17 Information and communication equipment	0.138	0.016	0.837	0.002	0.004	0.002	1.000
	18 Transport equipment	0.123	0.088	0.781	0.002	0.004	0.002	1.000
	19 Precision instruments	0.102	0.016	0.875	0.002	0.004	0.002	1.000
	20 Other manufactured articles	0.112	0.020	0.860	0.002	0.004	0.002	1.000
	21 Electricity, steam and hot water, and gas	0.130	0.004	0.862	0.000	0.002	0.001	1.000
	22 Water production and supply	0.036	0.005	0.957	0.000	0.001	0.000	1.000
	23 Construction	0.065	0.016	0.913	0.001	0.003	0.002	1.000
	24 Wholesale and retail trade	0.022	0.004	0.973	0.000	0.001	0.000	1.000
	25 Transport and warehousing	0.084	0.008	0.906	0.000	0.001	0.001	1.000
	26 Services	0.029	0.006	0.963	0.000	0.001	0.001	1.000

Table 8 (Continued) Regional Contribution to a One-Unit Increase in Each Final Demand, Measured by Induced Imports and Value Added

		Import	Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China	Total
Central Coast	1 Agriculture, forestry, and fisheries	0.072	0.001	0.008	0.811	0.049	0.060	1.000
	2 Crude petroleum and natural gas products	0.048	0.001	0.007	0.883	0.026	0.034	1.000
	3 Metal ore mining	0.090	0.001	0.012	0.729	0.073	0.095	1.000
	4 Coal mining and processing and others	0.100	0.001	0.012	0.706	0.082	0.099	1.000
	5 Food products and tobacco	0.096	0.001	0.009	0.713	0.081	0.100	1.000
	6 Textile products	0.156	0.002	0.025	0.625	0.092	0.100	1.000
	7 Articles of apparel, leather and furs	0.152	0.002	0.024	0.629	0.099	0.095	1.000
	8 Sawmill products and furniture	0.137	0.001	0.014	0.580	0.113	0.154	1.000
	9 Paper and pulp	0.151	0.001	0.018	0.645	0.085	0.099	1.000
	10 Petroleum processing and coking	0.213	0.001	0.008	0.370	0.152	0.256	1.000
	11 Chemicals	0.160	0.001	0.022	0.610	0.099	0.109	1.000
	12 Nonmetal mineral products	0.107	0.001	0.013	0.613	0.111	0.155	1.000
	13 Primary metals	0.162	0.002	0.021	0.465	0.138	0.212	1.000
	14 Metal products	0.156	0.002	0.022	0.542	0.115	0.162	1.000
	15 General machinery	0.181	0.003	0.030	0.545	0.102	0.139	1.000
	16 Electrical machinery	0.180	0.003	0.030	0.524	0.112	0.150	1.000
	17 Information and communication equipment	0.230	0.002	0.031	0.558	0.089	0.089	1.000
	18 Transport equipment	0.175	0.004	0.028	0.565	0.098	0.130	1.000
	19 Precision instruments	0.225	0.002	0.032	0.545	0.090	0.105	1.000
	20 Other manufactured articles	0.100	0.001	0.014	0.718	0.077	0.089	1.000
	21 Electricity, steam and hot water, and gas	0.087	0.001	0.011	0.588	0.123	0.191	1.000
	22 Water production and supply	0.077	0.001	0.010	0.738	0.076	0.097	1.000
	23 Construction	0.129	0.002	0.019	0.596	0.107	0.147	1.000
	24 Wholesale and retail trade	0.072	0.001	0.008	0.828	0.042	0.049	1.000
	25 Transport and warehousing	0.110	0.001	0.009	0.740	0.060	0.081	1.000
	26 Services	0.092	0.001	0.011	0.782	0.052	0.062	1.000
Other Coast	1 Agriculture, forestry, and fisheries	0.068	0.001	0.007	0.021	0.853	0.052	1.000
	2 Crude petroleum and natural gas products	0.103	0.001	0.014	0.021	0.804	0.057	1.000
	3 Metal ore mining	0.153	0.002	0.017	0.031	0.707	0.091	1.000
	4 Coal mining and processing and others	0.114	0.002	0.016	0.034	0.749	0.085	1.000
	5 Food products and tobacco	0.111	0.001	0.009	0.033	0.754	0.092	1.000
	6 Textile products	0.180	0.002	0.027	0.043	0.667	0.081	1.000
	7 Articles of apparel, leather and furs	0.208	0.002	0.032	0.053	0.622	0.083	1.000
	8 Sawmill products and furniture	0.155	0.001	0.017	0.058	0.638	0.132	1.000
	9 Paper and pulp	0.189	0.002	0.022	0.049	0.644	0.094	1.000
	10 Petroleum processing and coking	0.282	0.001	0.008	0.023	0.535	0.150	1.000
	11 Chemicals	0.193	0.002	0.026	0.051	0.627	0.102	1.000
	12 Nonmetal mineral products	0.139	0.002	0.017	0.040	0.687	0.115	1.000
	13 Primary metals	0.177	0.002	0.023	0.042	0.616	0.140	1.000
	14 Metal products	0.185	0.003	0.026	0.050	0.590	0.146	1.000
	15 General machinery	0.208	0.003	0.034	0.035	0.631	0.089	1.000
	16 Electrical machinery	0.196	0.003	0.031	0.049	0.602	0.118	1.000
	17 Information and communication equipment	0.439	0.003	0.059	0.046	0.387	0.066	1.000
	18 Transport equipment	0.206	0.005	0.034	0.044	0.612	0.100	1.000
	19 Precision instruments	0.266	0.003	0.037	0.049	0.531	0.115	1.000
	20 Other manufactured articles	0.130	0.001	0.019	0.042	0.717	0.090	1.000
	21 Electricity, steam and hot water, and gas	0.106	0.001	0.010	0.024	0.735	0.123	1.000
	22 Water production and supply	0.087	0.001	0.011	0.027	0.802	0.071	1.000
	23 Construction	0.139	0.002	0.020	0.041	0.677	0.121	1.000
	24 Wholesale and retail trade	0.097	0.001	0.011	0.021	0.821	0.050	1.000
	25 Transport and warehousing	0.120	0.001	0.012	0.024	0.770	0.072	1.000
	26 Services	0.107	0.001	0.012	0.022	0.807	0.052	1.000

Rest of China	1	Agriculture, forestry, and fisheries	0.025	0.000	0.003	0.017	0.034	0.921	1.000
	2	Crude petroleum and natural gas products	0.029	0.000	0.004	0.015	0.032	0.920	1.000
	3	Metal ore mining	0.067	0.001	0.007	0.033	0.069	0.823	1.000
	4	Coal mining and processing and others	0.044	0.001	0.005	0.027	0.057	0.866	1.000
	5	Food products and tobacco	0.035	0.000	0.004	0.025	0.055	0.881	1.000
	6	Textile products	0.056	0.001	0.008	0.045	0.072	0.818	1.000
	7	Articles of apparel, leather and furs	0.065	0.001	0.009	0.055	0.090	0.781	1.000
	8	Sawmill products and furniture	0.051	0.001	0.006	0.035	0.070	0.837	1.000
	9	Paper and pulp	0.060	0.001	0.007	0.041	0.082	0.810	1.000
	10	Petroleum processing and coking	0.092	0.001	0.005	0.023	0.082	0.798	1.000
	11	Chemicals	0.069	0.001	0.008	0.045	0.082	0.795	1.000
	12	Nonmetal mineral products	0.056	0.001	0.006	0.034	0.075	0.829	1.000
	13	Primary metals	0.080	0.001	0.008	0.040	0.090	0.783	1.000
	14	Metal products	0.075	0.001	0.009	0.044	0.089	0.782	1.000
	15	General machinery	0.079	0.001	0.011	0.047	0.090	0.772	1.000
	16	Electrical machinery	0.083	0.001	0.012	0.052	0.100	0.752	1.000
	17	Information and communication equipment	0.144	0.001	0.019	0.062	0.109	0.664	1.000
	18	Transport equipment	0.088	0.002	0.012	0.051	0.089	0.758	1.000
	19	Precision instruments	0.086	0.001	0.011	0.046	0.087	0.768	1.000
	20	Other manufactured articles	0.042	0.001	0.005	0.029	0.056	0.868	1.000
	21	Electricity, steam and hot water, and gas	0.041	0.001	0.005	0.024	0.058	0.871	1.000
	22	Water production and supply	0.042	0.001	0.005	0.026	0.054	0.872	1.000
	23	Construction	0.057	0.001	0.007	0.034	0.076	0.826	1.000
	24	Wholesale and retail trade	0.036	0.000	0.004	0.022	0.044	0.893	1.000
	25	Transport and warehousing	0.053	0.001	0.005	0.026	0.059	0.855	1.000
	26	Services	0.042	0.001	0.005	0.025	0.051	0.877	1.000

4. Simulation Analyses

We conducted two simulations using the estimated multiregional I-O table of Japan and China.

4.1 Evaluation of Regional Linkages in Terms of the Product Induced by Final Demand

First, we evaluated the interdependence between Aichi Prefecture and the two coastal regions in China from the product induced by final demand for each sector. Figures 11a and 11b show the induced product of the two coastal regions in China induced by the consumption and investment in Aichi Prefecture. The sectors largely affected by Aichi Prefecture's final products are textile products and apparel for both coastal regions in China, followed by chemicals. As regards the textiles sector, the Central Coast region is more affected than the Other Coast region, and for apparel the reverse is the case. On the other hand, the impact on China's machinery sectors from Aichi Prefecture's consumption and investment demand is not so great. We found that Aichi Prefecture's consumption goods affect both coastal regions in China more strongly than investment goods.

The effect of consumption and investment in the two Chinese coastal regions induced in each sector of Aichi Prefecture can be seen in Figures 12a and 12b. The impacts on general machinery and transport equipment in Aichi Prefecture are prominent, followed by primary metals, metal products and electrical machinery. We also found the effect of investment is stronger than that of consumption in both the figures. Even regarding the effect of consumption, the impact on transport equipment is the highest. Textile products, in which Aichi Prefecture has the comparative advantage in Japan, receive a relatively large impact.

Figure 11a Output Induced in Central Coast by Final Demand of Aichi Prefecture

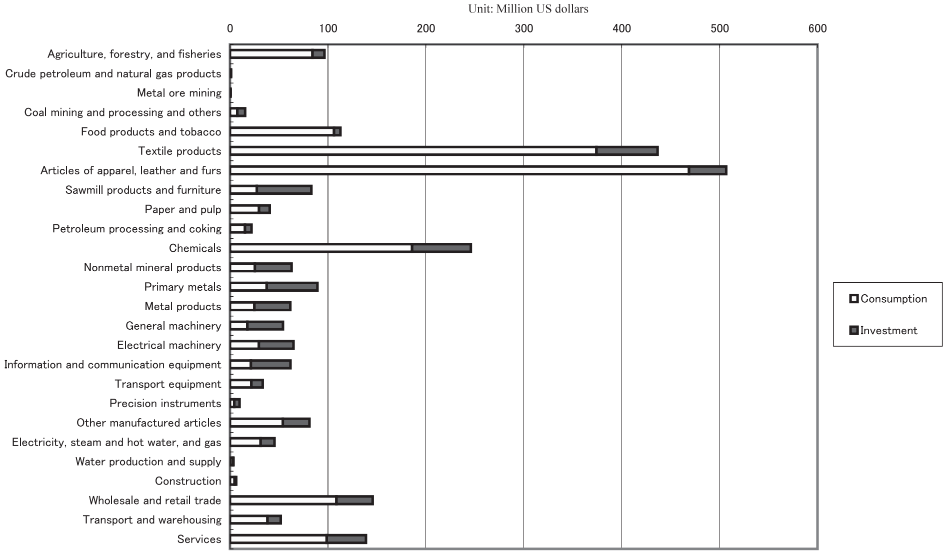


Figure 11b Output Induced in Other Coast by Final Demand of Aichi Prefecture

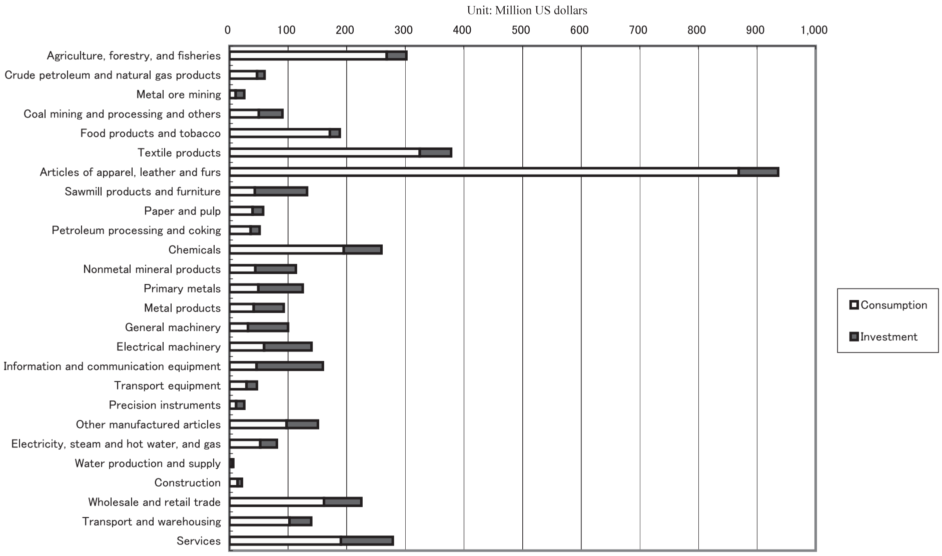


Figure 12a Output Induced in Aichi Prefecture by Final Demand of Central Coast

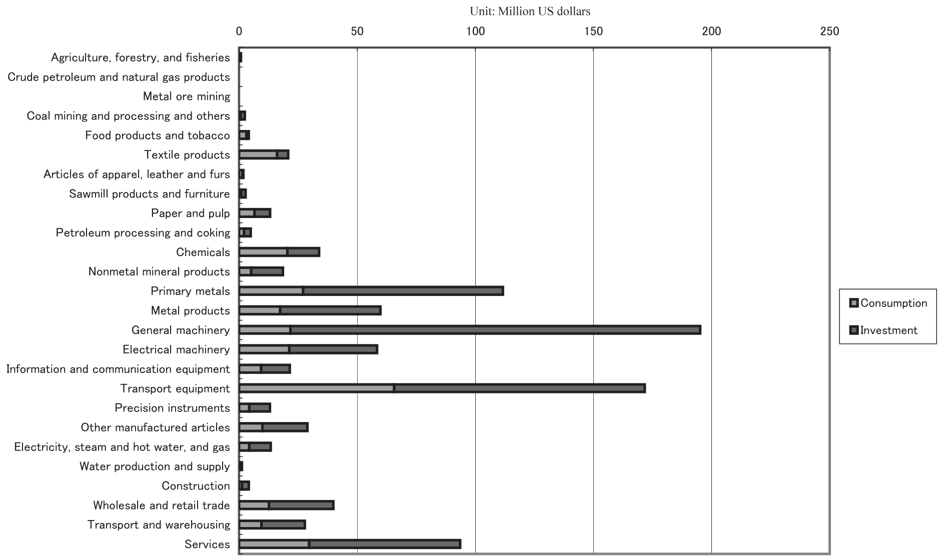
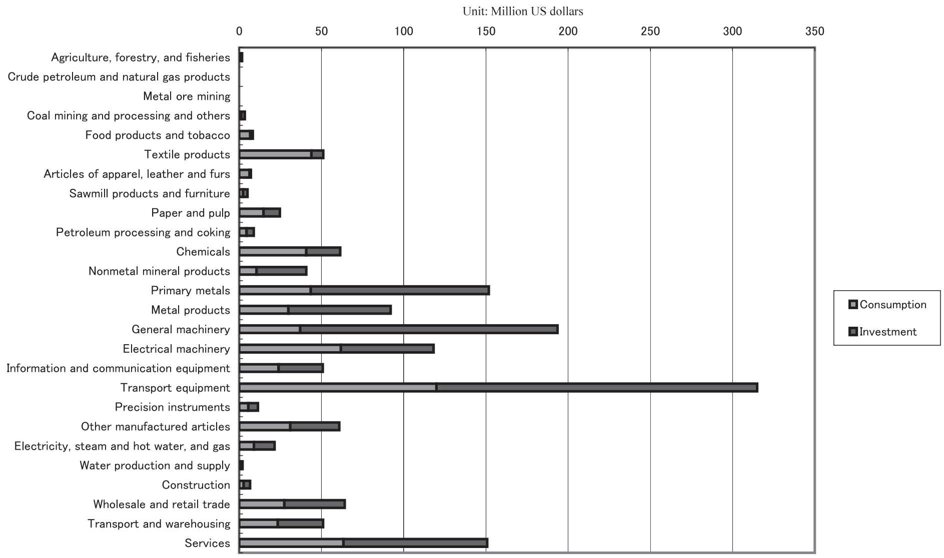


Figure 12b Output Induced in Aichi Prefecture by Final Demand of Other Coast



We examined the effect of exports to third countries, which can be seen in Figures 13a and 13b. Figure 13a shows the sectoral product of each region in China, induced by the exports of Aichi Prefecture to countries other than China, while Figure 13b shows the sectoral product of Aichi Prefecture induced by the exports of each region in China to countries other than Japan. From these figures, we found that the effect of Aichi Prefecture exports on China is strong in primary metals, chemicals, machinery sectors, textile products, and miscellaneous manufactured articles, as Chinese exports require Japan's material goods and parts. These effects are stronger in the case of exports from the coastal regions in China, although the effect on primary metals is strongest in the case of the non-coastal (rest of China) region in China.

On the other hand, transport equipment, primary metals, textile products, and chemicals undergo a pronounced effect due to the exports of the Chinese regions. Chinese apparel has a competitive advantage in the world market, the material products for which China in part obtains from Aichi Prefecture. The effects on Aichi Prefecture from both coastal regions of China are predominant, and that of the rest of China is very small.

Figure 13a Output Induced in Chinese Regions by Export Demand of Aichi Prefecture

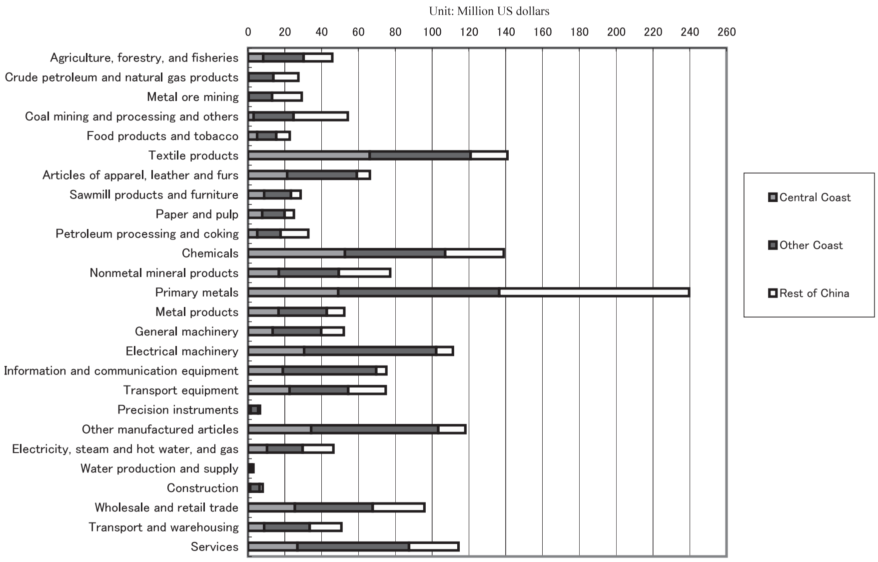
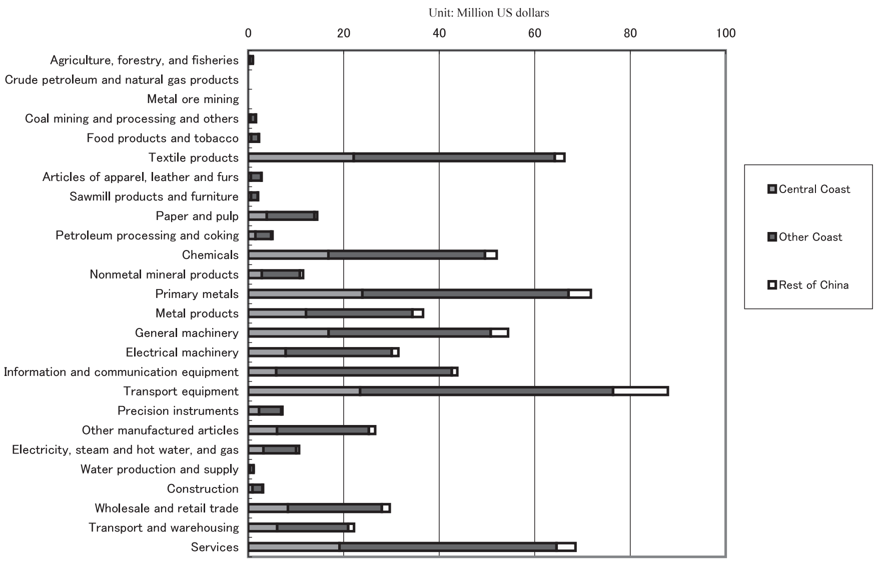


Figure 13b Output Induced in Aichi Prefecture by Export Demand of China



4.2 Direct Investment in China by Aichi Prefecture's Manufacturing Firms

We evaluated the regional effects from Aichi Prefecture's manufacturing firms investment in the two coastal regions.

First we assumed that information and communication equipment firms invest in the Central Coast region with a capacity for a one-percent increase on the production of US$0.17378 billion which the Japanese subsidiaries have in the region. The amount of production in Aichi Prefecture's information and communication equipment sector was US$11.31386 billion, and the assumed value is approximately 1.5 percent of Aichi Prefecture's production in the sector. Furthermore, we assumed that 40 percent of the increased product is exported to the Japanese market, and that the rest is sold in the local market or in a third country. Also, the domestic product for the sector for Aichi Prefecture was assumed to decrease by the same amount as the increase in imports from China- US$69.51 million. At the same time, we assumed that 40 percent of the intermediate inputs are purchased from Japan, 30 percent from the local market, and the rest from other countries around the world. These assumptions were determined by taking into account the regional shares of production sales and the regional shares of input purchases with respect to Japanese subsidiaries in the Chinese market (See Tables 9a and 9b, compiled from the METI Survey on Overseas Business Activities).

Tables 10a and 10b show the results. The increase in the production of Aichi Prefecture's firms in China affects the production in each Chinese region. Induced production in the Central Coast region is US$242.89 million, the Other Coast region US$20.35 million, and the rest of China US$16.45 million. Production in Aichi Prefecture also increases by US$5.60 million, production in the rest of Japan increases by US$110.85 million, and imports (from third countries) increase by US$14.65 million. The total increase amounts to US$410.79 million. The induced effect on Japan is US$116.45 million as a whole.

Conversely, the domestic decrease in production, replaced by imports from China, has a negative effect on internal production. Production decreases in Aichi Prefecture by US$98.55 million, and in the rest of Japan by US$58.18 million. China and third countries naturally suffer a negative effect; US$1.97 million and US$8.00 million, respectively.

The last column in Table 10a shows the overall effect, which is calculated as the sum of the two opposing effects: the induced effect and the replaced production effect. We find that a positive effect appears in the Central Coast region in China, with Aichi Prefecture firms investing there. A negative effect, however, is observed in Aichi Prefecture, with its firms expanding into China.

Table 10b shows the sectoral effect for each region. The predominant effects appear in the information and communication equipment sector of the Chinese Central Coast region and Aichi Prefecture, in opposite directions. The service sector experiences relatively large effects. In the rest of Japan, the positive effect induced by production in China partly offsets the negative effect brought about by the reduction in Aichi Prefecture production. The overall effect amounts to US$52.67 million. Japan as a whole, however, undergoes a net negative reduction in production of US$40.29 million, because the production in Aichi Prefecture is reduced by US$92.96 million, which is larger than that for the rest of Japan. In China, a positive effect in production is expected to the tune of US$277.72 million. For Aichi Prefecture's firms, which make overseas investments in China, the production shift from Aichi Prefecture to China yields more production as a whole, even though Aichi Prefecture's own production is reduced.

Table 9a Regional Sales Structure of Japanese Overseas Subsidiaries in China

China, 2000	Sales	Exports to Japan	Sales in China	Exports to Third Countries				
					North America	Asia	Europe	Other
Total	100.0	30.1	43.8	26.1	3.6	21.6	1.0	0.0
Manufacturing, Total	100.0	31.5	47.2	21.3	5.1	14.8	1.4	0.0
Food products	100.0	13.3	84.3	2.4	0.7	1.7	0.0	0.0
Textile products	100.0	46.8	41.1	12.2	3.4	7.9	0.9	0.0
Paper and pulp	100.0	1.3	96.8	1.9	1.3	0.6	0.0	0.0
Chemicals	100.0	11.3	78.1	10.6	0.8	9.3	0.6	0.0
Petroleum and coal	100.0	10.6	80.1	9.3	0.0	0.0	0.0	9.3
Iron and steel	100.0	3.2	83.0	13.8	0.3	13.4	0.1	0.0
Nonferrous metals	100.0	11.2	75.8	13.0	3.0	5.9	4.1	0.0
General machinery	100.0	53.5	25.8	20.7	0.2	20.3	0.2	0.0
Electrical machinery	100.0	31.9	38.3	29.8	6.7	21.5	1.6	0.0
Transport equipment	100.0	9.1	84.8	6.0	5.6	0.4	0.1	0.0
Precision instruments	100.0	60.7	30.3	9.0	3.6	2.7	2.7	0.0
Miscellaneous manufactured articles	100.0	25.5	57.4	17.1	9.2	4.2	3.6	0.0

China, 2001	Sales	Exports to Japan	Sales in China	Exports to Third Countries				
					North America	Asia	Europe	Other
Total	100.0	30.0	43.5	26.5	3.6	19.4	1.6	1.8
Manufacturing, Total	100.0	34.7	46.4	18.9	4.8	11.6	1.5	0.9
Food products	100.0	17.1	81.6	1.3	0.3	0.8	0.1	0.0
Textile products	100.0	58.3	32.3	9.4	3.0	6.0	0.2	0.2
Paper and pulp	100.0	6.6	92.0	1.4	1.4	0.0	0.0	0.0
Chemicals	100.0	12.2	71.7	16.1	0.3	15.2	0.6	0.1
Petroleum and coal	100.0	0.0	86.2	13.8	0.0	3.6	9.6	0.6
Iron and steel	100.0	2.2	91.2	6.6	0.0	6.6	0.0	0.0
Nonferrous metals	100.0	7.6	83.0	9.4	1.0	6.1	0.0	2.3
General machinery	100.0	56.9	24.5	18.6	2.2	15.0	1.2	0.2
Electrical machinery	100.0	26.2	35.5	38.3	20.9	13.4	3.4	0.7
Information and communication equipment	100.0	39.6	36.5	23.9	2.4	17.4	2.1	2.1
Transport equipment	100.0	14.2	82.2	3.6	1.9	1.4	0.1	0.1
Precision instruments	100.0	52.2	39.5	8.2	1.7	5.7	0.7	0.0
Miscellaneous manufactured articles	100.0	30.5	51.4	18.1	8.6	6.9	2.4	0.1

Note: This table is compiled from the data in the 31st and 32nd Surveys on Overseas Business Activities, METI, Japan.
Values for the information and communication equipment sector in 2000 are included in the electrical machinery sector.

Table 9b Regional Purchases Structure of Japanese Overseas Subsidiaries in China

China, 2000	Input Purchases	Imports from Japan	Purchases in China	Imports from Third Countries				
					North America	Asia	Europe	Other
Total	100.0	34.8	35.8	29.4	0.8	19.2	2.0	7.4
Manufacturing, Total	100.0	35.1	40.1	24.8	0.4	17.7	0.3	6.5
Food products	100.0	1.0	79.9	19.2	0.0	6.8	0.0	12.3
Textile products	100.0	40.7	39.4	19.9	0.3	14.8	0.4	4.4
Paper and pulp	100.0	11.0	84.8	4.3	2.9	0.0	1.3	0.0
Chemicals	100.0	36.1	51.0	12.9	1.1	10.7	0.8	0.4
Petroleum and coal	100.0	10.6	61.2	28.1	0.0	28.1	0.0	0.0
Iron and steel	100.0	59.7	30.6	9.6	0.0	7.4	0.0	2.2
Nonferrous metals	100.0	17.3	75.9	6.8	0.1	5.7	0.1	0.8
General machinery	100.0	36.3	54.6	9.1	0.2	8.3	0.0	0.6
Electrical machinery	100.0	32.2	31.3	36.5	0.3	25.8	0.1	10.3
Transport equipment	100.0	50.9	45.3	3.9	2.1	1.6	0.2	0.0
Precision instruments	100.0	46.0	51.9	2.1	0.1	2.0	0.0	0.0
Miscellaneous manufactured articles	100.0	28.8	56.1	15.1	1.3	10.6	3.0	0.2
China, 2001	**Input Purchases**	**Imports from Japan**	**Purchases in China**	**Imports from Third Countries**	**North America**	**Asia**	**Europe**	**Other**
Total	100.0	36.6	36.1	27.3	1.5	23.4	0.7	1.6
Manufacturing, Total	100.0	37.6	43.2	19.2	1.7	16.9	0.4	0.0
Food products	100.0	9.7	76.7	13.6	5.4	3.0	0.0	0.0
Textile products	100.0	41.3	53.0	5.7	0.4	5.0	0.1	0.0
Paper and pulp	100.0	12.0	87.9	0.1	0.1	0.0	0.0	0.0
Chemicals	100.0	32.2	34.6	33.2	17.9	14.1	1.1	0.0
Petroleum and coal	100.0	22.3	77.7	0.0	0.0	0.0	0.0	0.0
Iron and steel	100.0	70.4	19.9	9.7	0.0	7.7	2.0	0.0
Nonferrous metals	100.0	26.0	62.5	11.6	6.6	3.9	1.1	0.0
General machinery	100.0	33.3	62.3	4.4	0.2	4.2	0.0	0.0
Electrical machinery	100.0	27.7	36.2	36.1	0.4	35.7	0.1	0.0
Information and communication equipment	100.0	41.0	32.0	27.1	1.0	25.4	0.2	0.0
Transport equipment	100.0	36.8	59.3	3.9	2.1	1.1	0.7	0.0
Precision instruments	100.0	45.6	50.6	3.8	0.0	3.8	0.0	0.0
Miscellaneous manufactured articles	100.0	40.8	36.7	22.5	0.4	20.2	1.9	0.0

Note: This table is compiled from the data in the 31st and 32nd Surveys on Overseas Business Activities, METI, Japan.
Values for the information and communication equipment sector in 2000 are included in the electrical machinery sector.

Table 10a Regional Effects of Japanese Overseas Production in China: Information and Communication Equipment Sector

Units: million US dollars, %

	Local Production in China	Replaced Production in Japan	Induced Product by Local Production in China	Induced Product by Replaced Production in Japan	Overall Effect
Aichi		-69.51	5.60	-98.55	-92.96
Rest of Japan			110.85	-58.18	52.67
Central Coast	173.78		242.89	-0.49	242.40
Other Coast			20.35	-1.07	19.28
Rest of China			16.45	-0.41	16.04
Imports			14.65	-8.00	6.66
Japan, Total	0.00	-69.51	116.45	-156.74	-40.29
China, Total	173.78	0.00	279.69	-1.97	277.72
Total	173.78	-69.51	410.79	-166.70	244.09
Aichi		-40.00	3.22	-56.71	-53.49
Rest of Japan			63.79	-33.48	30.31
Central Coast	100.00		139.77	-0.28	139.49
Other Coast			11.71	-0.62	11.10
Rest of China			9.46	-0.24	9.23
Imports			8.43	-4.60	3.83
Japan, Total	0.00	-40.00	67.01	-90.19	-23.18
China, Total	100.00	0.00	160.94	-1.13	159.81
Total	100.00	-40.00	236.39	-95.93	140.46

Table 10b Regional Effects of Japanese Overseas Production in China: Information and Communication Equipment Sector

Unit: million US dollars

		Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China
1	Agriculture, forestry, and fisheries	-0.02	0.00	0.60	0.29	0.36
2	Crude petroleum and natural gas products	0.00	0.00	0.02	0.21	0.40
3	Metal ore mining	0.00	0.00	0.04	0.28	0.49
4	Coal mining and processing and others	-0.01	0.00	0.31	0.85	1.44
5	Food products and tobacco	-0.09	-0.03	0.45	0.23	0.24
6	Textile products	-0.02	0.07	0.64	0.18	0.14
7	Articles of apparel, leather and furs	-0.02	0.04	0.65	0.15	0.07
8	Sawmill products and furniture	-0.05	0.03	0.38	0.09	0.14
9	Paper and pulp	-0.48	0.13	1.79	0.34	0.21
10	Petroleum processing and coking	-0.08	0.22	0.62	0.39	0.52
11	Chemicals	0.05	4.41	7.30	1.92	1.46
12	Nonmetal mineral products	-0.95	0.24	3.33	0.69	1.09
13	Primary metals	-0.87	1.39	4.60	1.90	2.91
14	Metal products	-0.59	0.93	2.72	0.62	0.38
15	General machinery	0.00	0.70	1.18	0.40	0.40
16	Electrical machinery	0.24	3.01	1.41	0.30	0.17
17	Information and communication equipment	-70.76	29.90	194.42	5.37	1.09
18	Transport equipment	-0.13	0.02	0.90	0.26	0.34
19	Precision instruments	0.00	0.13	0.10	0.04	0.03
20	Other manufactured articles	-0.92	0.42	0.75	0.32	0.34
21	Electricity, steam and hot water, and gas	-0.88	0.67	2.09	0.60	0.64
22	Water production and supply	-0.09	0.16	0.16	0.04	0.03
23	Construction	-0.42	0.33	0.37	0.13	0.06
24	Wholesale and retail trade	-3.17	1.60	7.11	1.40	1.29
25	Transport and warehousing	-1.69	1.57	1.94	0.75	0.76
26	Services	-11.99	6.73	8.52	1.52	1.03
	Total	-92.96	52.67	242.40	19.28	16.04

Second we considered the scenario where Aichi Prefecture firms in the transport equipment sector invest in new production plants in the Other Coast region. We assumed a one-percent increase in local production in the transport equipment sector of US$185.94 million and 0.128 percent of the Aichi Prefecture production in the transport equipment sector of US$145.14961 billion. In the first simulation for the information and communication equipment sector, we considered that Japan was one of the major markets for the products. In this second simulation, however, the main market is considered to be China. In fact, a look at Table 9a reveals that the sales share for exports to the Japanese market is as low as 10 to 15 percent. Here we assumed that domestic production will decrease by 10 percent of the value of local production in China. Furthermore, regarding the regional shares in input purchases of the overseas subsidiaries in China (Table 9b), we assumed that half of the intermediate input will be imported from Japan, mainly from Aichi Prefecture, and the rest will be purchased in the local Chinese market.

Tables 11a and 11b show the results. The production of the transport equipment sector, US$185.94 million, induces production in the Other Coast region of US$320.20 million, in China as a whole of US$371.02 million, and in Japan as a whole of US$176.10 million-with US$37.96 million for Aichi Prefecture and US$138.14 million for the rest Japan, respectively. The induced production is larger than that in the information and communication equipment case.

As for the substitution effect, domestic production decreases by US$36.84 million in Aichi Prefecture, and US$14.65 million in the rest of Japan. These reductions amount to US$51.50 million in Japan as a whole. The effect in China is very low, US$0.51 million.

In this case, although the production of the transport equipment sector is reduced in Aichi Prefecture by the substitution effect, the internationally induced effect from Chinese production is slightly larger. Thus, the overall effect for Aichi Prefecture is an increase in production of US$1.11 million. No region has a negative overall effect.

Table 11b shows the sectoral effects for each region. The predominant effects appear in the transport equipment sector of the Other Coast region and the rest of Japan. The transport equipment sector in Aichi Prefecture only decreases in production by US$5.40 million, and all other sectors are expected to undergo a positive effect. Firms, naturally, have an incentive to invest in China, because their production, including overseas production, will increase.

Table 11a Regional Effects of Japanese Overseas Production in China: Transport Equipment Sector

Units: million US dollars, %

	Local Production in China	Replaced Production in Japan	Induced Product by Local Production in China	Induced Product by Replaced Production in Japan	Overall Effect
Aichi		-74.38	37.96	-36.84	1.11
Rest of Japan			138.14	-14.65	123.49
Central Coast			18.11	-0.13	17.98
Other Coast	185.94		320.20	-0.24	319.97
Rest of China			32.70	-0.14	32.56
Import			20.44	-2.00	18.44
Japan, Total	0.00	-74.38	176.10	-51.50	124.60
China, Total	185.94	0.00	371.02	-0.51	370.51
Total	185.94	-74.38	567.56	-54.00	513.55
Aichi		-40.00	20.41	-19.82	0.60
Rest of Japan			74.29	-7.88	66.42
Central Coast			9.74	-0.07	9.67
Other Coast	100.00		172.21	-0.13	172.08
Rest of China			17.59	-0.07	17.51
Import			10.99	-1.08	9.92
Japan, Total	0.00	-40.00	94.71	-27.69	67.01
China, Total	100.00	0.00	199.54	-0.27	199.26
Total	100.00	-40.00	305.24	-29.04	276.19

Table 11b Regional Effects of Japanese Overseas Production in China: Transport Equipment Sector

Unit: million US dollars

		Aichi	Rest of Japan	Central Coast	Other Coast	Rest of China
1	Agriculture, forestry, and fisheries	0.00	0.20	0.20	1.62	0.72
2	Crude petroleum and natural gas products	0.00	0.01	0.03	0.46	0.85
3	Metal ore mining	0.00	0.01	0.03	2.52	1.23
4	Coal mining and processing and others	0.00	0.15	0.18	2.69	2.19
5	Food products and tobacco	0.01	0.29	0.17	1.16	0.45
6	Textile products	0.11	0.55	0.40	0.95	0.28
7	Articles of apparel, leather and furs	0.01	0.16	0.26	1.25	0.17
8	Sawmill products and furniture	0.02	0.27	0.26	1.01	0.50
9	Paper and pulp	0.07	1.52	0.34	2.02	0.43
10	Petroleum processing and coking	0.06	1.64	0.40	1.91	1.32
11	Chemicals	0.18	5.06	2.64	7.99	2.42
12	Nonmetal mineral products	0.12	1.26	0.36	3.31	1.59
13	Primary metals	1.64	19.91	3.50	10.61	6.66
14	Metal products	0.28	2.76	0.54	8.97	0.68
15	General machinery	1.73	13.34	1.02	15.80	1.21
16	Electrical machinery	0.58	5.68	0.77	4.69	0.52
17	Information and communication equipment	0.15	3.96	0.36	0.73	0.16
18	Transport equipment	-5.40	30.09	2.32	209.35	2.43
19	Precision instruments	0.04	0.65	0.06	0.39	0.08
20	Other manufactured articles	0.43	5.06	0.50	1.89	0.82
21	Electricity, steam and hot water, and gas	0.08	2.26	0.58	4.81	1.36
22	Water production and supply	0.01	0.41	0.05	0.45	0.08
23	Construction	0.03	0.85	0.06	1.86	0.13
24	Wholesale and retail trade	0.17	5.02	1.21	10.56	2.73
25	Transport and warehousing	0.54	8.46	0.58	5.68	1.47
26	Services	0.26	13.95	1.18	17.30	2.07
	Total	1.11	123.49	17.98	319.97	32.56

5. Concluding Remarks

Based on the available input-output tables for the year 2000, we estimated an interregional I-O table between Japan and China, in which Aichi Prefecture in Japan and the Coastal regions in China were the focus. Using this table, we were able to evaluate the degree of interdependence between these regions in 2000.

We found that the interdependence between Aichi Prefecture and the Central Coast was not that strong via international trade, at least in the year 2000. We were able to observe, however, some difference in the pattern of influences. Capital goods in Japan are connected to the Chinese economy, while consumer goods in China are connected to the Japanese economy. After 2000, the interdependence via international trade between Japan and China has strengthened, so a regional interdependence would be expected in like manner.

Furthermore, we examined the impact of overseas production in the information and communication equipment and transport equipment sectors in the coastal regions. If the re-import effect, where imported goods substitute for domestic products in Japan, is strong, a reduction in product would occur. We found that the negative impact, brought about by overseas production in the transport equipment sector seeking a new market in China, is lower than that of the information and communication equipment sector which is shifting its domestic plants to China. Of course, this result heavily depends on the assumed scale of production and the degree of substitution.

Interregional input-output analysis between regions in different countries is one of the most valuable tools for the investigation of international trade and FDI, although more detailed information on the activity in foreign direct investment on a regional basis is necessary for this kind of analysis.

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