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Changing Industrial Linkage in the West Pacific: An International Input-Output Analysis[1]

By
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Abstract

This paper analyzes the industrial linkages between Japan and the rapidly growing Asian countries in the West Pacific, employing the multiplier decomposition analysis and the structural path analysis. The paper shows that industries in the developing countries of the West Pacific, as a whole, were increasingly becoming independent from their Japanese counterparts for the supply of goods and services required in their production activities. However, this total picture does not necessarily apply to the bilateral industrial linkages of Japan with the other individual countries of the region. On the contrary, the changes which were taking place at the bilateral level are of a diverse nature; some industries switched their relations away from Japanese industries, while some others intensified dependence on them. These changes in the production structure in the West Pacific had been taking place at a surprisingly rapid pace even before the G5 Plaza Agreement in 1985 which triggered the realignment of major currencies and caused massive relocations of production bases from Japan to the ASEAN countries and other parts of the region. The diversity of the changes in industrial linkages may suggest that the ongoing structural adjustment in the region could be a long lasting process.

1. Introduction

During the last two decades, the West Pacific region[2] has emerged as one of the most important concentrations of economic activities with the highest growth potential in the world economy. It is now generally recognized that the region constitutes one of the two growth poles in the Pacific, the other being the North American Free Trade Area (NAFTA). While a wider concept of regional integration in the form of the Asia–Pacific Economic Cooperation (APEC) is being pursued by governments in the Asia–Pacific region, the West Pacific is likely to remain as a unique subregion distinguishing from the other parts of the APEC region.

The West Pacific is composed of economies with diverse income and technological levels. At an early stage of structural adjustment in the region, the Asian NIEs were the major recipients of technologies and industries relocated from Japan. Relocation destinations shifted towards the ASEAN countries and then to the coastal provinces of China, as the NIEs joined Japan in the role of industrial transfer. Indochina has emerged as a new frontier of industrialization in the region. This pattern of industrial relocations is often referred to as the "flying geese" pattern of development (Yamazawa, et al. [1993]).

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[2] The term "West Pacific" refers to Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand as far as quantitative analyses in this paper are concerned. It sometimes refers to a wider region including China, Hong Kong, Taiwan and the Indochinese countries when qualitative statements are made.

Table 1: Total Backward Linkage Effects through Open Loop from the Six Countries on Japan

		1985	1975	85–75
8	Food product	.0068	.0055	.0013
9	Textile	.0826	.1437	-.0611
10	Wood product	.0144	.0332	-.0188
11	Paper & printing	.0511	.0981	-.0470
12	Chemical product	.1026	.1971	-.0945
13	Petroleum product	.0030	.0073	-.0043
14	Rubber product	.0656	.0817	-.0161
15	Non-metal mineral pro.	.0339	.0351	-.0012
16	Metal product	.1307	.2485	-.1178
17	Machinery	.2033	.1988	.0045
18	Transport equipment	.1925	.3221	-.1296
19	Other manufactures	.1068	.1689	-.0621

Note: See note to Table 2.

In my previous paper (Nakamura[1993]), I analyzed intertemporal changes in the industrial linkages between Japan, the US and the Asian developing countries using the multiplier decomposition analysis within an international input-output framework. Table 1 shows the increases in the total output of Japan induced by a unit increase in the output of the sectors as shown on the left hand side of the table of six Asian countries (Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand; hereafter referred to as the six-country case) through the open loop multipliers, the concept of which will be explained later. The differences between 1975 and 1985 indicate that the impacts of the output increases in the manufacturing sectors of the Asian developing countries had, in relative terms, decreased by a considerable degree. In other words, the manufacturing sectors of the developing part of the West Pacific were becoming less dependent on supply from Japanese industries.

However, due to the limitation of the multiplier analysis, I had to leave as a black box the exact mechanism through which the impacts were transmitted. The purposes of this paper are (i) to extract the basic features of industrial linkages between Japan and the other countries in the West Pacific, (ii) to investigate into the changes in the industrial linkages between 1975 and 1985 at the micro level, and (iii) to get an insight into the evolutions of the industrial linkages in the region after 1985 and into the future.

Section 2 describes the methodologies employed in this paper. Section 3 presents some empirical results, and section 4 provides the concluding remarks.

2. Multiplier Decomposition and Structural Paths

Let us consider a two-country input-output system as follows.

$$\begin{bmatrix} y_1 \\ \\ y_2 \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} y_1 \\ \\ y_2 \end{bmatrix} + \begin{bmatrix} x_1 \\ \\ x_2 \end{bmatrix}$$

where y is an output vector, x is a final demand vector, and B is an input coefficient matrix as it is usually defined. Subscripts denote country 1 and 2. As it is shown in Round [1985] and elsewhere, the Leontief inverse of the above system is multiplicatively decomposed as

$$y = M_{r3} M_{r2} M_{r1} x,$$

where, $D_{ij} = (I - B_{ii})^{-1} B_{ij}$,

$$M_{r1} = \begin{bmatrix} (I - B_{11})^{-1} & 0 \\ 0 & (I - B_{22})^{-1} \end{bmatrix},$$

$$M_{r2} = \begin{bmatrix} I & D_{12} \\ D_{21} & I \end{bmatrix}, and$$

$$M_{r3} = \begin{bmatrix} (I - D_{12}D_{21})^{-1} & 0 \\ 0 & (I - D_{21}D_{12})^{-1} \end{bmatrix}$$

M_{r1} represents the domestic multiplier matrix, which is similar to the one in a single-country system. Since D_{ij} represents the instantaneous effects on i of its supply of inputs to j after accounting for domestic multiplier effects in i, $D_{ij}D_{ji}$ gives the round-trip impacts on i induced by an output increase in i itself which is due to i's demand for j's products as intermediate inputs after the first round of repercussions. M_{r3} captures the multiplier effects after the repercussion effects between i and j are exhausted. In other words, it represents the inter-country feedback effects and is called a 'closed loop' multiplier matrix. The total 'own country' multiplier effect is obtained by multiplying the corresponding diagonal sub-matrices of M_{r1} and M_{r3}. M_{r2} captures the impacts transmitted from one country to the other after all 'own country' effects are accounted for by M_{r1} and M_{r3}, and it is referred to as an inter-country 'open loop' multiplier matrix. The diagonal sub-matrices of M_{r2} are identity matrices because all 'own country' effects are accounted for by the product of M_{r1} and M_{r3}.

2.1. The Structural Path Analysis

The structural path analysis considers a set of 'poles', and 'paths' through which influences of specific magnitude are transmitted between poles (for a standard explanation of the methodology, see Defourny and Thorbecke [1984]). The following simple example can be used to illustrate the methodology.

The example shows that there are two paths connecting X and Y ($X - S - T - Y$ and $X - U - Y$). $a..$'s represent the magnitude of influences carried through corresponding paths. In an input-output setting, the magnitude of influence can simply be defined as input coefficients (letting b_{ij} be the (i,j) element of an input coefficient matrix, $a_{ij} = b_{ji}$). Three types of influences are distinguished: (i) direct influence, (ii) total influence, and (iii) global influence.

The direct influence of X on Y through the first path, I^D_{XY}, is the change in Y induced by a unit change in X with all other poles except those along the path remaining constant, and it is measured by

$$I^D_{(X,S,T,Y)} = a_{XS}a_{ST}a_{TY}.$$

Similarly, the direct influence through the second path is

$$I^D_{(X,U,Y)} = a_{XU}a_{UY}.$$

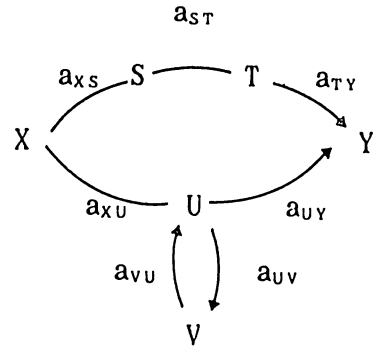

Figure 1

However, the influence through the second path is amplified by the circuit connecting U and V by the factor $1/(1-a_{UV}a_{VU})$. This factor is called a multiplier and the total influence through the second path, $I^T_{(X,U,Y)}$, is measured as

$$I^T_{(X,U,Y)} = a_{XU}a_{UY}/(1-a_{UV}a_{VU}) = a_{XU}a_{UY}m_{XUY},$$

where m_{XUY} is the multiplier accompanying this particular path. Finally, the global influence of X on Y is the sum of the total influences of all the paths connecting X and Y and, in this case, defined as

$$\begin{aligned} I^G_{(X.Y)} &= I^T_{(X,S,T,Y)} + I^T_{(X,U,Y)} \\ &= I^D_{(X,S,T,Y)} + I^D_{(X,U,Y)}m_{XUY} \end{aligned} \tag{1}$$

Let us now consider the application of the structural path analysis in an input-output setting by taking up a path going from activity i to j via k and l. The direct influence along the path is $b_{jl}b_{lk}b_{ki}$. The corresponding total influence is obtained as the product of the direct influences and the multiplier which amplifies the direct influence through adjacent feedback circuits. The multiplier is equal to the ratio of two matrix determinants D_{iklj}/D, where D is the determinant $|I-B|$, and, D_{iklj} is the determinant $|I-B_{iklj}|$, where B_{iklj} is a matrix identical to B except that it has unity in diagonal elements and zero in off-diagonal elements of the rows and columns for the sectors i,k,l and j. This relation can be generalized for paths consisting of any number of poles (see, Appendix 1). The global influence is nothing other than the (j,i) element of the Leontief inverse matrix, $(I-B)^{-1}$.

Next let us consider the relationship between the total influence and the corresponding open loop multiplier. If the Leontief inverse is partitioned as

$$(I-B)^{-1} = \begin{bmatrix} A_{11} & A_{12} \\ \\ A_{21} & A_{22} \end{bmatrix},$$

then the off-diagonal submatrices on the right hand side is decomposed as

$$A_{ij} = (I - D_{ij}D_{ji})^{-1}D_{ij}(I-B_{jj})^{-1}, \quad i \neq j.$$

As it is pointed out in my previous paper and other studies, a closed loop multiplier matrix in inter-regional setting tends to be almost identical to an identity matrix, hence,

$$D_{ij} \doteq A_{ij}(I - B_{jj})^{-1}.$$

Letting the (m, n) element of B_{jj}, D_{ij} and A_{ij} be b_{mn}, d_{mn} and a_{mn}, respectively,

$$d_{mn} \doteq (1 - b_{nn})a_{mn} - \sum_{k \neq n} b_{kn} a_{kn}$$

If a system does not allow 'own inputs'[3], i.e. $b_{nn} = 0$ (which is the case in this paper), the changes in d_{mn} and a_{mn} are nearly identical. Since a_{mn} represents the global influence of n on m and it is the sum of the total influences through all the paths connecting m and n, there is an approximate one to one correspondence between the change in the total influence of a particular path and that in the corresponding open loop multiplier.

3. Multiplier Decomposition and Structural Path Analyses Applied to Industrial Linkages between Japan and the Developing Countries in the West Pacific

The pattern of changes in the industrial linkages between Japan and the six Asian developing countries presented above could be the result of similar changes in each of the bilateral relations or those of a more diverse nature (A detailed analysis of bilateral industrial linkages in 1975 can be found in Furukawa [1986]). First, in order to examine this point, the open loop multipliers are calculated for bilateral industrial relations between Japan and three Asian developing countries: Korea, Malaysia and Thailand. Second, the major structural paths in the same bilateral relations are identified, and changes in them between 1975 and 1985 are investigated to examine what happened in individual production linkages.

The data source used is, as before, International Input-Output Table for ASEAN Countries 1975 (Institute of Developing Economies [1982]) and Asian International Input-Output Table 1985 (—[1992]). Computation is made on the basis of the 24-sector version of the tables.

3.1. Open loop multipliers between Japan and Korea, Malaysia and Thailand

Table 2 to 4 show the column totals of the open loop multiplier matrices (the total backward linkage effects through the open loop multiplier) computed for two-country systems consisting of one of the three Asian developing countries (Korea, Malaysia and Thailand) on an impact-generating side and Japan on a receiving side. The first row of Table 2, for instance, shows increases in the total output of the Japanese economy induced by a unit increase in the output of Korea's food product sector through the open loop multiplier. Though computation has been done based on the 24-sector system, results are shown only for 12 manufacturing sectors from which multiplier effects are relatively large.

The results for Korea (Table 2) show a very similar pattern to that observed for the sum of the six Asian countries. The magnitude of the open loop multiplier effects in 1975 is larger than that in the six-country case, and it is particularly so in the cases of chemical product and machinery sectors. The changes in the open loop multiplier effects between 1975 and 1985 are also generally larger than that in the six-country case. Fairly larger decreases are observed for the impacts from the chemical product, rubber product and metal product sectors. The change

[3]The diagonal elements of the original input-output table are deleted in order to avoid problems peculiar to "own inputs". The differences in data collecting practices (product basis or establishment basis, etc.) and other factors are the potential source of biases.

Table 2: Total Backward Linkage Effects through Open Loop from Korea on Japan

		1985	1975	85–75
8	Food product	.0046	.0059	-.0013
9	Textile	.0966	.1556	-.0590
10	Wood product	.0246	.0334	-.0088
11	Paper & printing	.0359	.0801	-.0442
12	Chemical product	.1175	.2649	-.1474
13	Petroleum product	.0050	.0095	-.0045
14	Rubber product	.0884	.2753	-.1869
15	Non-metal mineral pro.	.0259	.0221	.0038
16	Metal product	.1374	.3285	-.1911
17	Machinery	.2117	.2288	-.0171
18	Transport equipment	.1487	.2487	-.1000
19	Other manufactures	.1118	.1906	-.0788

Note: Figures in this table represent the column totals of the off-diagonal submatrix, D_{21}, of the open loop multiplier matrix.

Table 3: Total Backward Linkage Effects through Open Loop from Malaysia on Japan

		1985	1975	85–75
8	Food product	.0234	.0054	.0180
9	Textile	.1061	.1703	-.0642
10	Wood product	.0125	.0155	-.0030
11	Paper & printing	.1012	.1445	-.0433
12	Chemical product	.0717	.0973	-.0256
13	Petroleum product	.0019	.0044	-.0025
14	Rubber product	.0322	.0308	.0014
15	Non-metal mineral pro.	.0482	.0359	.0123
16	Metal product	.1918	.0605	.1313
17	Machinery	.1838	.1598	.0240
18	Transport equipment	.4815	.2332	.2483
19	Other manufactures	.1022	.1013	.0009

Note: See note to Table 2.

Table 4: Total Backward Linkage Effects through Open Loop from Thailand on Japan

		1985	1975	85–75
8	Food product	.0062	.0042	.0020
9	Textile	.0524	.1064	-.0540
10	Wood product	.0088	.0126	-.0038
11	Paper & printing	.0625	.0833	-.0208
12	Chemical product	.1092	.1479	-.0387
13	Petroleum product	.0013	.0044	-.0031
14	Rubber product	.0519	.0614	-.0095
15	Non-metal mineral pro.	.0184	.0192	-.0008
16	Metal product	.1561	.2105	-.0544
17	Machinery	.1572	.2223	-.0651
18	Transport equipment	.2127	.3052	-.0925
19	Other manufactures	.0515	.1121	-.0606

Note: See note to Table 2.

in the multiplier effect from the transport equipment sector is slightly less than the six-country average. However, in this sector, the magnitude of the open loop effect itself is smaller than the six-country average. Thus, the changes in the pattern of industrial linkages between Japan and Korea are representative of the trends in the West Pacific.

A drastically contrasting picture can be found in changes in the industrial linkages between Japan and Malaysia (Table 3). The latter's metal product and transport equipment sectors substantially increased their influences on the Japanese economy during the period in which the same industries of the developing countries of the West Pacific as a whole moved into opposite direction. The magnitude of the open loop multipliers from these two sectors is smaller than the six-country averages in 1975, but they grew much larger than the averages by 1985. The multiplier from the other manufacture sector remained unchanged, and that from the chemical product sector shows a small decline, as compared with much larger negative changes which took place in the six-country case.

The results for the open loop multiplier effects from Thailand on Japan represent an intermediate case. The directions of the changes are the same as those observed in the six-country case, but the magnitude of the changes is, in general, relatively modest. An exception is the effect from the country's machinery sector, which shows a substantial decline against a small positive change in the six-country case.

Thus, the weakening open loop multiplier effect from the developing part of the West Pacific on Japan, or former's increasing independence on inputs from Japan, is not uniformly observed in every bilateral relation. Rather, it is the outcome of very diverse changes in the industrial linkages in the region. It is not necessarily easy, however, to get a clear image of the changes in individual inter-industry linkages through which multiplier impacts are transmitted, from only the information obtained by the multiplier analysis above. The next part of this section investigates into what were taking place in the linkages between individual sectors by applying the structural path analysis.

3.2. Structural Path Analysis of Industrial Linkages in the West Pacific

The structural path analysis is applied to the international input-output table in the following manner. First, for every pair of sectors belonging to different countries, ten sectors which have the largest input coefficients in the input structure of the influencing sector of the pair are selected. Then a set of another ten sectors for each of the ten sectors chosen in the previous stage is selected in the same way. The direct influences through these paths are computed as the products of the corresponding input coefficients. In continuing this process, the direct influences decline rapidly as the number of multiplications increases. The selection process is terminated when the influence receiving sector of the initial pair is reached within three multiplications and with the direct influence of not less than 0.001. Finally, for each path connecting the pair, the multiplier and the total influence are calculated.

Table 5 shows, as an example, the results of the analysis of the influences from the machinery sector of the same six developing countries of the West Pacific on the Japanese industries. Three chemical and heavy industrial sectors (chemical product, metal product and machinery), and two service sectors (commerce/transport and services) of Japan are on the influence-receiving side. This relation represents a typical pattern of industrial interdependence between the developing part of the West Pacific and Japan, in which manufacturing sectors of developing countries of the region influence the key manufacturing sectors of Japan, and the latter then gives impacts on the service sectors of the country.

A comparison between the results for 1975 and 1985 in Table 5 reveals that (i) the magnitude of influences generally declined during the decade (except the intra-industry influence between the machinery sectors of the two sides, which, unlike many other cases, offsets the decrease in influences through other paths), (ii) some of the paths influencing the services sector of Japan

Table 5: Influences of the Six Countries' Machinery Sector on Japan

(1975)

Six Countries		Japan					Total Influence and Multipliers
Ma	Me	Ch	Me	Ma	Co	Se	
○	○						.0067
							.0135 / .0095
○		○					.0237
○			○				.0128
			○				
							.0517 / .0380
○			○				.0688
							.0711 / .0695
○				○			.0103
○			○		○		.0020
○				○			.0011
			○		○		.0273 / .0237
○				○		○	.0018
○		○				○	.0014
○			○			○	.0029
○				○			.0016
		○				○	
○			○			○	.0101
							.0279 / .0237
Total global influ. / Open loop multiplier							.2350 / .1988

(1985)

Six Countries		Japan					Total Influence and Multipliers
Ma	Me	Ch	Me	Ma	Co	Se	
○		○					.0029
○				○			.0016
		○					.0099 / .0070
○			○				.0161
○				○			.0119
			○				
○	○		○				.0055
							.0356 / .0284
○				○			.0878
							.0900 / .0864
○					○		.0099
○			○		○		.0017
○				○			.0013
			○		○		.0267 / .0238
○					○	○	.0020
○				○		○	.0128
							.0274 / .0244
Total global influ. / Open loop multiplier							.2296 / .2033

Note: Flows of influences go from left to right in this table. The thickness of lines corresponds to the magnitude of the total influences shown on the right-hand side. The global influences and the open loop multipliers between the pairs of sectors (separated by "/" in this order) are shown at the right-hand bottom of the table. For the abbreviations of sector names, see Appendix B.

selected in 1975 are not important any more in 1985, and (iii) the metal product sector of the developing part of the West Pacific emerges on the influence-receiving side in 1985. These three observations are more or less valid for many other paths of influence between the developing countries of the region and Japan. They may imply that the manufacturers of the region including Japan were increasingly becoming independent from services provided by Japanese trading houses and its banking sector, as they replaced these services by their own activities and by switching to local services including those from Japanese subsidiaries which started operations during the decade of the analysis. Influences in the opposite direction, i.e., those from Japan on the developing part of the West Pacific, are not detected in this analysis except for a few paths, but the number of such paths increased between 1975 and 1985. Thus, although a one-way nature of industrial linkages in the West Pacific did not change, the findings above may suggest that the production linkages in the region became more proliferated and shifted towards a more evenly distributed pattern.

Our next interest is, as in the multiplier decomposition analysis, whether the pattern of changes observed above is also found in bilateral relations between Japan and individual developing countries in the West Pacific. The same analysis is applied to two-country systems

Table 6: Influences of Korea's Chemical Product Sector on Japan

(1975)

Korea Ch	Japan Pp Ch Pe Ma Om Pu Co Se	Total Influence and Multipliers
○ ——— ○		.0012
○ ——— ○		.0046
○ —		.0086 / .0078
○ ═══ ○		.1341
		.1361 / .1336
○ ——— ○		.0017
○ ——— ○		.0011
○ ——— ○		.0119
○ ——— ○ ——— ○		.0010
○ ———		.0214 / .0182
○ ——— ○ ——— ○		.0022
		.0062 / .0040
○ ——— ○ ——— ○		.0028
		.0045 / .0041
○ ——— ○ ——— ○		.0070
		.0094 / .089
○ ═══ ○		.0133
○ ——— ○		.0022
○ —		.0334 / .0303
○ ——— ○ ○		.0023
○ ═══ ○ ═══ ○		.0282
		.0410 / .0385
Total global influ. / Open loop multiplier		.2866 / .2649

(1985)

Korea Ch	Japan Pp Ch Pe Ma Om Pu Co Se	Total Influence and Multipliers
○ ——— ○		.0020
○ —		.0033 / .0029
○ ——— ○		.0593
		.0611 / .0589
○ ——— ○		.0029
○ ——— ○ ○		.0040
		.0094 / .0083
○ ——— ○ ——— ○		.0011
		.0026 / .0018
○ ——— ○ ——— ○		.0043
		.0057 / .0052
○ ——— ○		.0060
		.0144 / .0130
○ ——— ○ ○		.0012
○ ——— ○ ——— ○		.0097
		.0166 / .0151
Total global influ. / Open loop multiplier		.1298 / .1175

Note: See note to Table 5.

consisting of Japan and one of the same three Asian countries as before: Korea, Malaysia and Thailand. Due to the limitation of space, only the results for sectors whose open loop multiplier effects underwent significant changes are shown.

Table 6 presents the major paths through which the influences from Korea's chemical product sector are transmitted to Japan for the years 1975 and 1985. The total open loop multiplier effect, received by all the Japanese industries, declined from 0.2649 in 1975 to 0.1175 in 1985 as indicated in the bottom row of the table. More than half of the decline is due to shrinking intra-industry input between the chemical product sectors of the two countries. Many paths selected in 1975 are not picked up in 1985 and the total influences through surviving paths decreased in magnitude. Table 7 shows that a greater change took place in the open loop multiplier effect from Korea's metal product sector (0.3285 $\longrightarrow$ 0.1374). Similar to the case of the country's chemical product sector, almost all the total influences declined significantly and the influences transmitted onto Japan's commerce/trade and services sectors almost disappeared.

Table 8 shows the influences from Thailand's transport equipment sector. The pattern of changes is, although to a lesser extent, very similar to those observed in the case of Korea's two industries. The intra-industry influence was reduced by more than a half between 1975 and 1985, and a few paths are not selected in 1985. However, both the global influences and the open loop multiplier effect from the sector on Japan's chemical and metal product sectors increased slightly. This means that a part of the intra-industry influence was replaced by those through

Table 7: Influences of Korea's Metal Product Sector on Japan

(1975)

Korea Me	Japan Ch Pe Nm Me Ma Pu Co Se	Total Influence and Multipliers
		.0033
		.0020 .0108 / .0071
		.0073
		.0012
		.0014
		.0192 .0356 / .0323
		.0040
		.0024 .0076 / .0069
		.1738 .1770 / .1744
		.0054
		.0022 .0119 / .0090
		.0094 .1216 / .0116
		.0124
		.0017
		.0146 .0376 / .0343
		.0022
		.0025
		.0214 .0378 / .0350
Total global influ. / Open loop multiplier		.3513 / 3285

(1985)

Korea Me	Japan Ch Pe Nm Me Ma Pu Co Se	Total Influence and Multipliers
		.0021
		.0011 .0070 / .0042
		.0015
		.0043 .0088 / .0077
		.0028
		.0041 / .0037
		.0699 .0720 / .0705
		.0056
		.0015 .0102 / .0077
		.0042
		.0075 .0164 / .0148
		.0015
		.0163 / .0146
Total global influ. / Open loop multiplier		.1517 / .1374

Note: See note to Table 5.

more roundabout routes involving more local fabrication in Thailand.

Tables 9 and 10 present the results for the influences of Malaysia's metal product and transport equipment sectors, which again show contrasting patterns to those examined so far. The total open loop multiplier effect from the metal product sector on the Japanese industries intensified more than threefold, and that from the transport equipment sector increased dramatically during the decade of the analysis. Unlike the findings in the previous cases, the intra-industry influences in these two cases intensified significantly, and, in the case of the metal product sector, many new paths (in particular, those involving Japan's commerce/transport and services sectors) have emerged by 1985. It may be interesting to note that significant open loop multiplier effects from Malaysia's transport equipment sector on Japan's metal product and machinery sectors remained in spite of sharp decreases in the total influences transmitted through the selected paths. This is because influences through more roundabout routes connecting these pairs of sectors have intensified. The dramatic increase in the intra-industry influence in transport

Table 8: Influences of Thailand's Transport Equipment Sector on Japan

(1975)

Thailand Tr	Japan Ch Pe Me Ma Tr Pu Co Se	Total Influence and Multipliers
○ —— ○		.0020 .0123 / .0075
○ —— ○	○ —	.0030 .0126 / .0106
○ —— ○		.0274
○ —— ○	○ —	.0065 .0604 / .0518
○ —— ○		.0348 .0519 / .04798
○ —— ○		.0939 .0954 / .0947
○ —— ○ —— ○		.0015 .0070 / .0060
○ —— ○		.0085
○ —— ○ — ○		.0075
○ —— ○ —— ○		.0023 .0331 / .0297
○ —— ○—○		.0015
○ —— ○——○—○		.0013
○ —— ○ —— ○		.0034
○ —— ○ —— ○		.0051 .0372 / .0327
Total global influ. / Open loop multiplier		.3388 / .3052

(1985)

Thailand Tr	Japan Ch Pe Me Ma Tr Pu Co Se	Total Influence and Multipliers
○ —— ○		.0061 .0139 / .0104
○ —— ○	○ —	.0027 .0075 / .0064
○ —— ○		.0447
○ —— ○	○ —	.0031 .0613 / .0539
○ —— ○		.0231 .0318 / .0287
○ —— ○		.0429 .0439 / .0433
○ —— ○		.0070
○ —— ○ — ○		.0038
○ —— ○ —— ○		.0048 .0251 / .0224
○ —— ○—○		.0014
○ —— ○ —— ○		.0034 .0259 / .0230
Total global influ. / Open loop multiplier		.2380 / .2187

Note: See note to Table 5.

equipment between the two countries is presumably due to the inception of Malaysia's national car project; a joint venture in which a Japanese car maker is heavily involved.

Why do changes in industrial linkages in different bilateral relations reveal such diversity? Several factors may be responsible for it. First, the market size of countries should be pointed out. Unless the size of domestic demand is large enough, the usual process of import substitution and export expansion may not take place in several sectors simultaneously in a continuous manner. The size factor also has to do with the scope of industrial sectors of a country. Whether a smooth endogenous process of import substitution of a certain sector takes place or not would depend on the existence of domestic supporting industries. Second, the diversity may also due to a policy stance toward foreign investment. Korea and Taiwan have basically relied on their indigenous enterprises, while the ASEAN countries have been making utmost efforts to introduce foreign capital for industrial development. With advanced foreign technologies and export markets which already existed, foreign subsidiaries in these countries could directly go into an export expansion process without undergoing import substitution. However, the subsidiaries more often than not require supplies from their parent firms in their build-up periods.

It is not surprising that there is a clear contrast between the patterns of industrial development between Korea and Malaysia, which have adopted distinct policies toward foreign investment and are very much different in population size (43 and 18 million for Korea and Malaysia, respectively). Thus, the structural adjustment in the West Pacific has not been a process in which technologies, capital and other production factors shifted smoothly from one

Table 9: Influences of Malaysia's Metal Product Sector on Japan

(1975)

Malaysia	Japan								Total Influence and Multipliers
Me	Ch	Pe	Me	Ma	Tr	Om	Co	Se	
O			O						.0038
			O						.0053 / .0048
O			O						.0341
									.0536 / .0344
O			O						.0013
									.0029 / .0011
O			O			O			.0029
									.00504/ .00448
O			O					O	.0042
									.0074 / .0065
Total global influ. / Open loop multiplier									.0676 / .0605

(1985)

Malaysia	Japan								Total Influence and Multipliers
Me	Ch	Pe	Me	Ma	Tr	Om	Co	Se	
O			O						.0015
			O						.0052 / .0040
O			O						.0057
			O						.0088 / .0081
O			O						.0932
O			O						.0021
			O						.0983 / .0955
O			O						.0158
O			O				O		.0021
									.0224 / .0187
O						O			.0015
									.0053 / .0024
O						O			.0014
									.0035 / .0030
O						O			.0057
O			O			O			.0100
									.0225 / .0204
O						O		O	.0012
O			O			O		O	.0020
O			O			O			.0023
									.0227 / .0207
Total global influ. / Open loop multiplier									.2101 / .1918

Note: See note to Table 5.

country to another of the region based on changing comparative advantages. Rather, it has been more ad hoc and dynamic in nature.

4. Concluding Remarks

This paper has analyzed the changing pattern of industrial linkages in the West Pacific using the multiplier decomposition and structural path analyses. The major findings of the paper are, (i) the manufacturing sectors of developing countries of the West Pacific, on average, became more independent of Japanese industries between 1975 and 1985, (ii) the number of important paths carrying influences from the developing part of the region on Japan decreased, in particular those influencing Japan's service sectors, and (iii) findings (i) and (ii) do not necessarily pertain to bilateral industrial linkages between Japan and individual developing countries of the West Pacific.

With respect to the third point, Korea seems to have led the changes described in (i) and (ii), while Malaysia moved into the opposite direction. Thailand can be placed in the middle. This diverse nature of the changes may seem to fit into the so-called flying-geese-type development hypothesis, which claims that industries of different strata of income and technological levels shift from one economy of the region to another. However, taking into consideration the higher per capita income of Malaysia than those of Korea and Thailand in the middle of the decade of the analysis, one would find that industries do not necessarily "fly" from low income countries

Table 10: Influences of Malaysia's Transport Equipment Sector on Japan

(1975)

Malaysia Tr	Japan Ch Pe Me Ma Tr Pu Co Se	Total Influence and Multipliers
O — O		.0022 .0093 / .0061
O — O O —		.0075 .0132 / .0126
O — O		.0680 .0833 / .0795
O — O		.0069 .0167 / .0154
O — O		.0539 .0554 / .0545
O — O — O		.0037 .0068 / .0063
O — O — O		.0043
O — O — O		.0057 .0186 / .0173
O — O — O		.0084
		.0262 / .0242
Total global influ. / Open loop multiplier		.2495 / .2332

(1985)

Malaysia Tr	Japan Ch Pe Me Ma Tr Pu Co Se	Total Influence and Multipliers
O — O		.0039 .0394 / .0378
O — O		.0022 .0275 / .0266
O — O		.2399 .2408 / .2404
O — O		.0197
O — O — O		.0212
		.0543 / .0536
O — O — O		.0040
O — O — O — O		.0043 .0491 / .0485
Total global influ. / Open loop multiplier		.4873 / .4815

Note: See note to Table 5.

to higher ones. More complex processes seem to have been at work behind the changes observed in this paper.

Foreign direct investments of Japanese firms in the ASEAN countries and other parts of the West Pacific have undoubtedly been the driving forces of structural changes in the industrial linkages in the region. The diverse nature of the changes in industrial production network is perhaps attributable to the strategies of multinational corporations of relatively advanced countries of the region, which take into account not only wage costs of different countries but economic fundamentals such as basic infrastructures and the availability of space and so forth. Government policies may have also had certain effects on their decisions.

It has generally been recognized, however, that the relocation of production bases from Japan to the developing part of the West Pacific started on a massive scale only after the rapid appreciation of the yen after late 1985. In fact, Japanese foreign direct investment increased tremendously in the later half of the 1980's with the total amount of investment of 227 billion US dollars (at current prices) in the five-year period from 1986 being 4.8 times the corresponding figure for the preceding 5 years. It is not difficult to imagine that the structural changes in the industrial network in the West Pacific after 1985 would have been much more intensive than those observed in this paper. If one is to get any insight from the present analysis, the changes after 1985 would have most probably continued to be of a dynamic nature, which do not fall in a uniform pattern. This may also suggest that the structural adjustment in the West Pacific could be a long-lasting process which will continue well into the next century.

Appendix A

Multiplier in the Structural Path Analysis

Let

$$I - B = A,$$

and the (i,j) element of A^{-1} be $[A^{-1}]_{ij}$, then,

$$[A^{-1}]_{ij} = A_{ji}/|A|,$$

where A_{ji} is the (j,i) co-factor of A. By expanding A_{ji} with respect to row i, one gets,

$$A_{ji} = -b_{ij}(A_{ji})_{ij} - \sum_{k \neq j} b_{ik}(A_{ji})_{ik}$$

where $(A_{ji})_{ij}$ is the (i,j) co-factor of (A_{ji}), which is identical to A except that its (j,i) element is unity and all the other elements in rows and columns i and j are zero, and it will be written as $A_{ji.ij}$ afterwards. By exchanging rows i and j as follows, one obtains,

$$A_{ji.ij} = \begin{array}{c} \\ i \\ \\ j \\ \\ \end{array} \begin{array}{c} \begin{array}{ccccccc} & & & & i & & j \end{array} \\ \begin{bmatrix} 1-b_{11} & \cdot & 0 & \cdot\cdot & 0 & \cdot\cdot & -b_{1n} \\ \cdot & & \cdot & & \cdot & & \cdot \\ 0 & \cdot\cdot & 0 & \cdot\cdot & 1 & \cdot\cdot & 0 \\ \cdot & & \cdot & & \cdot & & \cdot \\ 0 & \cdot\cdot & 1 & \cdot\cdot & 0 & \cdot\cdot & 0 \\ \cdot & & \cdot & & \cdot & & \cdot \\ -b_{n1} & \cdot & 0 & \cdot\cdot & 0 & \cdot & 1-b_{nn} \end{bmatrix} \end{array} = - \begin{array}{c} \begin{array}{ccccccc} & & & & i & & j \end{array} \\ \begin{bmatrix} 1-b_{11} & \cdot & 0 & \cdot\cdot & 0 & \cdot\cdot & -b_{1n} \\ \cdot & & \cdot & & \cdot & & \cdot \\ 0 & \cdot\cdot & 1 & \cdot\cdot & 0 & \cdot\cdot & 0 \\ \cdot & & \cdot & & \cdot & & \cdot \\ 0 & \cdot\cdot & 0 & \cdot\cdot & 1 & \cdot\cdot & 0 \\ \cdot & & \cdot & & \cdot & & \cdot \\ -b_{n1} & \cdot & 0 & \cdot\cdot & 0 & \cdot & 1-b_{nn} \end{bmatrix} \end{array}$$

$$= -A_{ii.jj}.$$

Likewise, $A_{ji.ik} = -A_{ii.jk}$, and hence,

$$A_{ji} = b_{ij}A_{ii.jj} + \sum_{k \neq j} b_{ik}A_{ii.jk}.$$

By further expanding $A_{ii.jk}$ with respect to row k, and continuing the same manipulation, one arrives at,

$$\begin{aligned} A_{ji}/|A| &= b_{ij}A_{ii.jj}/|A| \\ &\quad + \sum_{k \neq j} b_{ik}b_{kj}A_{ii.kk.jj}/|A| \\ &\quad + \sum_{k \neq j} \sum_{l \neq j} b_{ik}b_{kl}b_{lj}A_{ii.kk.ll.jj}/|A| \\ &\quad + \sum_{k \neq j} \sum_{l \neq j} \sum_{m \neq j} b_{ik}b_{kl}b_{mj}A_{ii.kk.ll.jm}/|A|. \end{aligned}$$

The left-hand side represents the global influence, while the first three terms on the right-hand side are the products of the direct influences and the ratios of two matrix determinants. The last term on the right-hand side can be further decomposed, and therefore the multipliers accompanying paths consisting of any number of poles can be defined as the ratio of the two matrix determinants.

Appendix B

Sector Classification used in this Analysis

		(abbreviation)
1	Paddy	
2	Other agricultural products	
3	Livestock	
4	Forestry	
5	Fishery	
6	Crude petroleum and natural gas	
7	Other mining	
8	Food, beverage and tobacco	
9	Textile and leather	
10	Timber and wooden products	
11	Pulp, paper and printing	(Pp)
12	Chemical products	(Ch)
13	Petroleum and products	(Pe)
14	Rubber products	(Ru)
15	Non-metallic mineral products	(Nm)
16	Metal products	(Me)
17	Machinery	(Ma)
18	Transport equipment	(Tr)
19	Other manufactures	(Om)
20	Public utilities	(Pu)
21	Construction	
22	Commerce and transport	(Co)
23	Services	(Se)
24	Public administration	

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