

A DPG (Deviation from Proportional Growth) Analysis of the Japanese, Korean and Taiwanese Economies¹

By

Chen Kuang-hui* and Kiyoshi Fujikawa**

Abstract

A version of DPG analysis, a method to identify quantitatively the pattern of growth in terms of "Deviations from Proportional Growth," is presented and applied to the I-O data of Japan, Korea and Taiwan. The presented version includes an original definition of DPGs and the use of "normalized DPGs," the aim of which is to supply clearer outputs of the method. The analysis of the three economies contrasts the export-led Korean and Taiwanese growth with the Japanese growth, where the contribution of investment demand and intermediate demand had long been significant.

1. Introduction

The purpose of this article is to present a method to explain quantitatively the causes of observed change in the sector composition of production and apply it to the data of Japan, Korea and Taiwan in order to compare their patterns of growth.

Our method has its origin in Chenery (1960), who intended to give a systematic explanation to the empirical fact that there exists a certain pattern of change in the composition of output, a fact which was pointed out in the works of Clark, Kuznets and Rostow.² Chenery's approach was to combine several factors that had been known as the causes of that pattern, an example of which was the change of household consumption investigated by Houthakker (1957). He presented a method to introduce a concept, "Deviation from Proportional Growth," as a measure of the degree of change in output composition and to break it down into several factors, a method which we refer to as DPG analysis.

Although Chenery applied his DPG analysis originally to "the normal production levels of industries" calculated from data of some 50 countries, various versions have later been developed and applied as methods to identify the pattern of growth of a specific economy.³ We can find those versions applied to the data of Japan in the studies of Chenery, Shishido and Watanabe (1962), and Watanabe and Suruga (1977); of Korea in Aoki and Inada (1980), and Han (1989); and of Taiwan and Japan in Chen and Fujikawa (1987 and 1989). Variation of the methods, however, does not allow a consistent comparison between their results.

In this article, we apply our version to these three economies. Our analysis covers the period 1914-85 for Japan, 1963-85 for Korea and 1966-84 for Taiwan. We believe that it is quite

Manuscript received December 17, 1991. Revised February 20, 1992.

*Junior College Course of Economics, Shiga University.

**Osaka University of Economics, and the International Centre for the Study of East Asian Development, Kitakyushu.
¹We would like to thank Mitsuo Saito, Shuntaro Shishido and an anonymous referee, as well as Takahiro Akita, Schunichi Hiraki and participants at the 1991 meeting of the Japan Section of the Regional Science Association International for their invaluable comments and discussions.

²For example, see Clark, 1957; Kuznets, 1966; and Rostow, 1960.

³We made a brief survey of those methods in Chen and Fujikawa, 1989.

meaningful to make a comparison of growth patterns between Japan, including the pre-war period, and the Newly Industrializing Economies in Asia.

We set forth our method in the next section. We make an analysis of the Japanese, Korean and Taiwanese economies in Section 3. Section 4 contains concluding remarks.

2. Method

DPG analysis measures the degree of change in sector composition of production in terms of the concept of deviations from proportional growth. The deviations, which we call DPGs, can be defined as:

$$\delta X = X_{t+1} - \lambda X_t \quad (1)$$

where

X_t, X_{t+1} : the column vectors each element of which is gross production of each sector in time period t and $t + 1$

λ : the scalar which represents the (weighted) average ratio of expansion of production, obtained by the division of the total of the gross production in period $t + 1$ by that of period t

δX , a vector of DPGs, is zero if all the sectors have expanded at the average ratio, λ , which corresponds to the situation of proportional growth. Each element of δX is DPG of each sector. It is positive when a sector has grown faster than the average, zero when the ratio of expansion of the sector is equal to λ , and negative when it is less than λ . Hence, its sign shows whether a sector has increased its output share or not, and its absolute value depends on the actual growth rate and the production level of the sector. The DPGs thus defined are analogous to deviations around the mean. The sum of them therefore is zero.⁴

DPG analysis decomposes δX into several factors. Our formula for the decomposition is based on the following balance equation:

$$X_t = (ii' - M^A_t) * A_t X_t + (I - M^C_t) C_t + (I - M^{I_f}_t) I_f_t + J_t + E_t \quad (2)$$

where

ii' : the matrix all elements of which are 1

$*$: Hadamard product of matrices⁵

A_t : the matrix of input coefficients

M^A_t : the matrix the (i,j) th element of which is the import coefficient of the (i,j) th intermediate transaction

I : the identity matrix

C_t, I_f_t : the vectors of final consumption and investment

$M^C_t, M^{I_f}_t$: the diagonal matrices the (i,i) th elements of which are the import coefficients of the i -th consumption and the i -th investment

J_t, E_t : the vectors of increases in stocks and of exports of domestic products

⁴These characteristics of the DPG resulted from our λ in equation (1) being the average ratio of expansion of industries, instead of which the ratio of expansion of per capita income, total domestic demand, GNP or GDP has often been chosen.

⁵If $A = (a_{ij})$ and $B = (b_{ij})$, then their Hadamard product is $A * B = (a_{ij}b_{ij})$. See Rao 1973, 30.

The first term of the equation represents intermediate demand for domestic industries. The second term and the third represent consumption and investment demand. The fourth and the fifth are increases in stocks and exports of domestic goods and services. The equation states that the production of each sector is equal to the sum of demand for domestic products.

Solving equation (2) for X_t gives:

$$X_t = [I - (ii' - M^A_t) * A_t]^{-1} [(I - M^C_t) C_t + (I - M^{If}_t) If_t + J_t + E_t] \quad (3)$$

It expresses that production is a function of final demand vectors, C_t , If_t , J_t and E_t , with import coefficient matrices and an input coefficient matrix, M^A_t , M^C_t , M^{If}_t and A_t , working as parameters.⁶ We can now attribute a change in production to changes in those vectors and/or parameter matrices, to which changes we can attribute the DPGs of production as well.

Substituting (3) into (1) yields the following decomposition formula:

$$\begin{aligned} \delta X = & B_{t+1} (I - M^C_{t+1}) \delta C + B_{t+1} (I - M^{If}_{t+1}) \delta If + B_{t+1} \delta J + B_{t+1} \delta E \\ & + B_{t+1} (M^C_t - M^C_{t+1}) \lambda C_t + B_{t+1} (M^{If}_t - M^{If}_{t+1}) \lambda If_t + B_{t+1} (M^A_t - M^A_{t+1}) * A_t \lambda X_t \\ & + B_{t+1} (ii' - M^A_{t+1}) * (A_{t+1} - A_t) \lambda X_t \end{aligned} \quad (4)$$

where

$$\begin{aligned} B_{t+1} &= [I - (ii' - M^A_{t+1}) * A_{t+1}]^{-1} \\ \delta C &= C_{t+1} - \lambda C_t \\ \delta If &= If_{t+1} - \lambda If_t \\ \delta J &= J_{t+1} - \lambda J_t \\ \delta E &= E_{t+1} - \lambda E_t \end{aligned}$$

The first term represents the DPGs of production attributable to the DPGs of consumption demand, δC , the i -th element of which is positive, zero, and negative when the i -th demand has expanded at a ratio greater than, equal to and smaller than λ . The second, third, and fourth terms are the analogous deviations of production resulted from the DPGs of investment demand, δIf , the DPGs of increases in stock, δJ , and of exports, δE . The fifth, sixth and seventh terms represent the effects produced by changes in import coefficients of consumption, $M^C_t - M^C_{t+1}$, of investment, $M^{If}_t - M^{If}_{t+1}$, and of intermediate demand, $M^A_t - M^A_{t+1}$. The last term is DPGs attributable to a change in input-output coefficients, $A_{t+1} - A_t$.

Although equation (4) is the basic formula for our DPG analysis, it requires rather detailed information on imports, information which is not always available. We prepared a revised model that is applicable even if data are less detailed. We replaced equations (2), (3) and (4) with the following:

$$X_t = (I - M_t) (A_t X_t + C_t + If_t + J_t) + E_t \quad (5)$$

where

M_t : the diagonal matrix the (i,i) th element of which is the import coefficient of the i -th domestic

⁶This is an input-output model which treats imports as endogenous variables. There are alternative models where imports are exogenous variables and production is a function of final demand vectors and import vector(s), with an input coefficients matrix working as parameters. An example of these alternatives can be found in Chenery, Shishido, and Watanabe, 1962. The reasons why we choose an endogenous imports model are that we assume imports are strongly related with domestic demands, that the import coefficients would provide better indices of degree of import dependency than imports levels, and that models of this type seem to be used more often in recent studies.

demand, which is the total of intermediate, consumption, investment demand and an increase in stocks

J_t : the vector representing increases in stocks including imported goods

$$X_t = [I - (I - M_t) A_t]^{-1} [(I - M_t) (C_t + I_f + J_t) + E_t] \quad (6)$$

$$\begin{aligned} \delta X = & B_{t+1} (I - M_{t+1}) \delta C + B_{t+1} (I - M_{t+1}) \delta I_f \\ & + B_{t+1} (I - M_{t+1}) \delta J + B_{t+1} \delta E \\ & + B_{t+1} (M_t - M_{t+1}) \lambda (A_t X_t + C_t + I_f + J_t) \\ & + B_{t+1} (I - M_{t+1}) (A_{t+1} - A_t) \lambda X_t \end{aligned} \quad (7)$$

where

$$B_{t+1} = [I - (I - M_{t+1}) A_{t+1}]^{-1}$$

This revised model decomposes δX into six factors, the effects of the deviations of final demand, δC , δI_f , δJ and δE , and the effects of changes in import coefficients and input coefficients, $M_t - M_{t+1}$ and $A_{t+1} - A_t$.

Our decomposition analysis includes four periods, 1914-54, 1955-65, 1965-75 and 1975-85, for Japan; two periods, 1963-75 and 1975-85, for Korea; and two periods, 1966-76 and 1976-84, for Taiwan. We applied equation (7) for Japan in the period 1914-54 and (4) for all the others.⁷ Data were obtained from the input-output tables for the beginning and the ending year of each period. We aggregated the original tables, which were composed of about 50-120 sectors of production, into 20- to 30-sector tables and then converted them into ones expressed in constant prices. See Appendix for more detailed information on the data.

Table 1 illustrates the result of the decomposition analysis. The first column shows the DPG of each sector, the number of which is reduced by re-aggregating the result obtained from the data of the 20- to 30- sector tables.⁸ The remaining columns show the sources of each DPG. The formula applied here was equation (7) and thereby the sources included deviations of four categories of final demand, consumption, investment, increases in stocks and exports; and changes in two categories of coefficients, import coefficients and input coefficients. However, the effect regarding increases in stocks is, and will be in the analysis below, excluded. This is because we are concerned with DPGs over a period longer than the accepted length of the cycle of inventory change, about three years.

Table 1 Illustration of the Result of DPG Decomposition

	DPG	Deviation of			Change in Coef.	
		C	I _f	E	M	A
Agriculture, Forestry, & Fisheries	-2348.9	-1435.7	43.1	-152.1	-287.5	-527.8
Mining	-143.7	-83.7	56.7	-46.4	-52.3	-1.3
Chemicals	544.9	-328.4	63.8	-28.4	493.9	363.5
Metals	1119.8	-258.7	288.0	120.8	351.2	697.3
Machinery	231.4	-197.7	170.1	57.5	60.2	154.3
Other Manufacturing	227.4	-812.9	220.8	-388.0	197.7	1178.4
Construction	322.2	-106.3	349.8	-0.7	5.7	75.4
Trade	490.0	12.8	81.5	-43.4	25.5	429.7
Others	-443.1	-1562.1	274.5	-266.0	180.6	973.5
Total	0.0	-4771.8	1548.3	-746.7	975.1	3342.5

⁷We could not obtain input-output coefficients for Japan in 1914 and eliminated A_t in equation (7) by replacing $A_t X_t$ with W_t , the vector of the total intermediate demand in period t .

⁸See Tables A through H at the end of this article for sector classification.

Table 1 indicates, in terms of DPG, the direction, degree, and the sources of change in the composition of output. This is the result for Japan in 1914-54 and the values are expressed in millions of 1951 yen. As far as we are concerned with the relative degree of the change and the relative magnitude of the causes, however, they do not have to be measured by a specific money unit. They can be divided by the sum of DPGs that are positive and then multiplied by 100,⁹ thereby being normalized so that the sum of positive DPGs equals 100 and that of negative DPGs equals -100, as is shown in Table 2 in the next section. This normalization would make the table clearer and the comparison between periods and economies easier. Every table presented in the next section shows such a normalized result.

3. Major Findings

3.1. The Japanese Economy

The results of our DPG decomposition for Japan in the periods 1914-54, 1955-65, 1965-75 and 1975-85 are given in Tables 2, 3, 4 and 5.

3.1.(1) 1914-54

DPGs in Table 2 indicate that manufacturing, trade and construction increased their output shares and that mining, "others," agriculture, forestry and fisheries decreased their shares. Manufacturing and construction accounted for 83.3% of the positive deviations. Japan in this period is thus characterized by its industrialization.

The last row of the table shows that change in input coefficients played the most significant part in producing positive deviations. Every sector received its benefit except agriculture, forestry, fishery and mining. We assume this is because the development of various industrial sectors in this period, some of which might be "newborn," caused intermediate demand to shift toward a direction in favor of those industries.

The deviation of investment was the second important factor that produced positive deviations. Among three categories of final demand in Table 2, only investment was a factor where the total

Table 2 DPG Decomposition for Japan, 1914-54

	DPG	Deviation of			Change in Coef.	
		C	I ^f	E	M	A
Agriculture, Forestry, & Fisheries	-80.0	-48.9	1.5	-5.2	-9.8	-18.0
Mining	-4.9	-2.9	1.9	-1.6	-1.8	—
Chemicals	18.6	-11.2	2.2	-1.0	16.8	12.4
Metals	38.1	-8.8	9.8	4.1	12.0	23.8
Machinery	7.9	6.7	5.8	2.0	2.1	5.3
Other Manufacturing	7.7	-27.7	7.5	-13.2	6.7	40.1
Construction	11.0	-3.6	11.9	—	0.2	2.6
Trade	16.7	0.4	2.8	-1.5	0.9	14.6
Others	-15.1	-53.2	9.3	-9.1	6.2	33.2
Total	0.0	-162.5	52.7	-25.4	33.2	113.9

Note: The annual growth rates of GDP, consumption, investment and exports, calculated from I-O data for 1914 and 1954 at 1951 constant prices, are 2.8%, 2.2%, 5.2% and 2.6% respectively.

⁹The sum of DPGs that are positive is equal to the absolute sum of DPGs that are negative, since the sum of DPGs, according to our definition, is equal to zero.

contribution was positive. The reason is that only investment demand, as the note at the end of the table suggests, expanded at a ratio greater than λ , the average ratio of output expansion. Most elements of $\delta I_f = I_{f,t+1} - \lambda I_{f,t}$ in equation (4) could thus have positive values and produce positive DPGs. Consumption and exports, on the contrary, could not expand at ratios sufficient to make their total contributions positive.

The third factor the total effect of which was positive was change in import coefficients, a factor the positive effect of which suggests import substitution took place. Import substitution explained a fair part of the positive DPGs of chemicals, metals and "other manufacturing."

3.1.(2) 1955-65

Table 3 indicates that "other manufacturing" and trade, the DPGs of which sectors had been positive in the previous period, did not increase their shares. The sectors the deviations of which were positive were chemicals, metals, machinery and construction. Japan in this period was thus characterized by the expansion of heavy industries.

A change is also observed in the sources of DPGs. Change in input coefficients, having been the most significant source in the previous period and still explaining a fair part of positive deviations of chemicals and machinery, could not favor so many sectors as before and its total effect turned negative. Change in import coefficients, a source which had been the third important, was no longer a considerable cause of industrial expansion, suggesting that import substitution was almost completed.

The factors the total effects of which were positive in this period were the deviations of investment and exports. As the note at the end of Table 3 suggests, their expansion was considerably large so that not a few sectors could receive its linkage effects. The table shows us that the growth of investment benefited all sectors, among which machinery and construction were conspicuous, and that exports benefited machinery, metals and chemicals. It might seem strange that the total effect of export growth was much less than that of investment growth, whereas the difference between their rates of growth was only a little. Our reasoning for this is that the exports were smaller in amount than the investment.

3.1.(3) 1965-75

As DPGs shown in Table 4 indicate, Japanese pattern of growth in this period was characterized by

Table 3 DPG decomposition for Japan, 1955-65

	DPG	Deviation of			Change in Coef.			
		C	I_f	E	M^C	M^I	M^A	A
Agriculture, Forestry, & Fisheries	-38.1	-5.7	1.5	-0.4	-0.8	—	—	-28.8
Mining	-2.4	0.1	0.7	—	—	—	-2.4	-1.0
Chemicals	18.7	3.7	2.3	2.3	-0.1	—	-0.8	11.1
Metals	18.0	3.4	8.5	6.8	—	0.1	-2.2	1.1
Machinery	56.4	8.0	22.4	9.7	—	0.2	-0.1	16.6
Other Manufacturing	-1.8	4.7	7.9	-2.1	-0.5	—	-1.7	-10.2
Construction	7.3	-0.6	13.9	-0.8	—	—	—	-5.1
Trade	-3.8	-4.2	4.7	-1.2	—	—	-0.1	-3.0
Others	-53.9	-7.1	6.4	-3.7	-0.3	—	-0.2	-49.1
Total	0.0	2.2	68.5	10.5	-1.7	0.3	-7.5	-68.5

Note: The annual growth rates of GNP, consumption, investment and exports, calculated from national accounts data for 1955 and 1965 at 1960 constant prices, are 9.7%, 8.0%, 15.0% and 14.4% respectively.

Table 4 DPG Decomposition for Japan, 1965-75

	DPG	Deviation of			Change in Coef.			
		C	If	E	M ^c	M ⁱⁱ	M ^A	A
Agriculture, Forestry, & Fisheries	-19.3	-10.6	-1.0	-0.9	-0.7	—	-3.3	-1.8
Mining	-6.0	0.1	-1.2	0.1	-0.4	—	-3.1	-1.4
Chemicals	—	-1.3	-2.5	2.6	-1.1	—	—	3.2
Metals	10.6	-0.4	-7.8	10.2	-0.3	—	0.7	7.8
Machinery	29.2	2.3	2.9	17.1	-0.8	0.2	-0.3	9.1
Other Manufacturing	-30.4	-19.0	-8.7	-3.5	-2.4	-0.1	-2.8	9.6
Construction	-44.3	0.2	-39.4	0.1	—	—	—	-5.2
Trade	2.2	-2.2	-1.7	0.9	-0.3	—	-0.3	6.2
Finance	15.5	0.8	-1.9	1.0	-0.3	—	-0.5	16.7
Public Services	10.7	9.3	-0.2	0.2	—	—	—	1.3
Others	31.9	15.0	-6.3	3.7	-1.0	—	-1.5	22.8
Total	0.0	-5.8	-67.7	31.4	-7.4	0.2	-11.1	68.3

Note: The annual growth rates of GNP, consumption, investment and exports were 11.3%, 8.3%, 17.5% and 16.1% respectively in the first half of this period and dropped to 4.7%, 5.5%, 3.3% and 11.3% in the second half. The figures were calculated from national accounts data for 1965, 1970 and 1975 at 1970 constant prices.

the continuing expansion of heavy industries and the newly observed enlargement of services including “others,” although chemicals, a sector that belongs to heavy industries, no longer increased its share.

Conspicuous is that the deviation of investment, which had been a significant cause of positive DPGs, turned to be a negative factor in this decade. Investment slumped after the quadrupling of oil prices in 1973 and could not continue to lead the growth of industries.

Significant sources of positive DPGs in this decade were change in input coefficients and the deviation of exports. The former was an important source of the positive deviations of “others” and finance, and the latter played a considerable role in the expansion of machinery and metals. The former fact suggests that a change took place in the pattern of intermediate demand necessitating more services than before.

The table shows us that the enlargement of service sectors was also supported by the deviation of consumption. A change in favor of services seems to have taken place in the pattern of consumption as well.

Change in import coefficients continued to be a factor the total effect of which was negative, suggesting that imports had been increasing. We assume this was a result of the fact that the expansion of exports made more imports possible.

3.1.(4) 1975-85

In this decade, expansion of machinery sector accounted for almost 70% of the positive DPGs and that of trade, finance and public services accounted for the rest, as shown in Table 5.

The factors the total effects of which were positive were the deviation of exports and that of consumption. The former, the total effect of which was more than twice as large as that of the latter, was more significant for machinery and the latter was rather more significant for services.

Conspicuous in this decade are thus the export-led expansion of the machinery sector and the consumption-led expansion of services, with the former accounting for 33.0% and the latter accounting for, when “others” is excluded from services, 19.8% of the positive deviations.¹⁰ The

¹⁰The figure 19.8 is obtained by the addition of 11.8, 6.1 and 1.9, DPGs of services, from which “others” is excluded, explained by the deviation of consumption.

Table 5 DPG Decomposition for Japan, 1975-85

	DPG	Deviation of			Change in Coef.			
		C	I ^f	E	M ^C	M ^I	M ^A	A
Agriculture, Forestry, & Fisheries	-7.7	-3.9	-0.2	—	—	—	—	-2.9
Mining	-3.0	0.1	-0.7	—	-0.1	—	—	-2.3
Chemicals	-14.0	2.4	-1.8	-0.1	0.3	—	-3.6	-10.6
Metals	-10.9	0.2	-7.4	-2.5	—	0.2	-1.6	0.2
Machinery	68.8	8.9	13.3	33.0	0.2	—	0.3	10.0
Other Manufacturing	-6.1	-7.0	-6.5	2.4	-0.1	—	-1.1	5.9
Construction	-36.5	0.2	-35.8	0.1	—	—	—	-0.9
Trade	18.2	11.8	—	3.8	—	—	-0.6	3.1
Finance	6.4	6.1	-1.4	1.6	-0.1	—	-0.5	0.6
Public Services	6.5	1.9	-0.1	0.8	—	—	-0.1	3.9
Others	-21.9	-6.2	-7.8	-0.9	-0.6	0.2	0.7	-7.7
Total	0.0	14.6	-48.5	38.3	-0.5	0.5	-6.5	-0.8

Note: The annual growth rates of GNP, consumption, investment and exports, calculated from national accounts data for 1975 and 1985 at 1980 constant prices, are 4.5%, 3.5%, 3.5% and 9.4% respectively.

factors except the deviation of exports and consumption could not make their total effects positive, whereas all of them played some part in producing positive deviations of machinery.

3.2. The Korean Economy

Tables 6 and 7 give the results for Korea in 1963-75 and 1975-85. Korea has been known as one of Asian NIEs, which have achieved rapid growth and the promotion of industry through an export-oriented policy. We found several characteristics that seemed to have resulted from its development strategy.

3.2.(1) 1963-75

Table 6 shows that manufacturing DPGs amount to 94.5% of the positive deviations. The Korean economy in this period is thus characterized by the expansion of its manufacturing sector.

Table 6 DPG Decomposition for Korea, 1963-75

	DPG	Deviation of			Change in Coef.			
		C	I ^f	E	M ^C	M ^I	M ^A	A
Agriculture, Forestry, & Fisheries	-70.6	-62.6	0.8	3.2	-4.8	—	-1.7	0.5
Mining	-2.6	-1.1	0.3	0.1	—	—	-1.9	—
Chemicals	23.4	-7.1	0.9	11.7	-0.5	0.1	6.7	11.5
Metals	11.3	-0.6	2.5	6.4	-0.1	0.2	2.3	0.7
Machinery	25.6	4.4	6.8	12.0	-0.1	0.8	-0.9	1.7
Other Manufacturing	34.2	-6.5	1.7	40.6	-0.8	0.1	-0.2	-0.2
Construction	5.5	-0.9	6.7	-0.2	—	—	—	—
Trade	-9.9	-10.4	1.7	5.7	-0.1	0.1	0.3	-6.1
Finance	-5.7	-10.7	1.0	1.3	-0.1	—	0.1	2.7
Others	-11.2	-18.6	1.6	8.6	0.4	0.1	0.3	-4.5
Total	0.0	-114.0	24.0	89.3	-6.4	1.3	4.9	6.1

Note: The annual growth rates of GDP, consumption, investment and exports, calculated from national accounts data for 1963 and 1975 at 1970 constant prices, are 10.1%, 8.0%, 16.6% and 31.0% respectively.

The most significant source of this manufacturing expansion was the deviation of exports. The table suggests that Korea exported a variety of manufactures and that the exports increased at a remarkably rapid rate. Almost every sector could benefit from it.

The second source of the manufacturing expansion was the deviation of investment. Although being inferior to the exports, the growth of investment was considerably rapid and every sector could receive its linkage effect.

The effects of change in import coefficients and change in input coefficients, which explained a fair part of the positive deviations of chemicals, were not significant on the whole. The deviation of consumption could not have any positive effects.

There are some similarities between the Korean pattern of growth in this period and the Japanese pattern in 1914-54. Every sector of manufacturing increased its share and the deviation of investment was a significant source. The difference is that exports played a remarkable role in the Korean case, whereas the effects of change in input coefficients and import coefficients were significant in Japan.

3.2.(2) 1975-85

In this decade, there took place a change in the pattern of manufacturing expansion whereby chemicals decreased its output share. However, manufacturing still accounted for a large part, 92.7%, of the positive DPGs, as shown in Table 7.

A change also took place in the sources of DPGs. The significance of investment and exports decreased and the favorable effects of change in input coefficients and import coefficients increased.

Our reasoning for the decreased significance of investment and exports is that they could not expand as rapidly as before. Korea also experienced a recession in the decade following the quadrupling of oil prices in 1973, although the growth of the Korean economy was still rapid, for instance, in comparison with Japan.

In spite of the recession, the Korean economy seems to have matured more than the previous period. We can find increased significance of change in input coefficients and import coefficients M^A and M^{If} , a situation which suggests intensified interindustry linkages and the progress of import substitution of intermediate and investment goods. The fact that the deviation of exports favored heavy industries, which fact suggests that heavy manufactures increased their share in

Table 7 DPG Decomposition for Korea, 1975-85

	DPG	Deviation of			Change in Coef			
		C	If	E	M^C	M^{If}	M^A	A
Agriculture, Forestry, & Fisheries	-59.9	-61.7	-0.8	-6.7	3.7	—	5.1	0.6
Mining	-5.4	-1.0	-0.2	0.8	—	—	-1.1	-1.9
Chemicals	-0.4	-13.7	-0.7	8.5	0.2	0.5	3.1	4.2
Metals	23.6	-1.2	-0.7	6.6	—	0.9	5.0	5.8
Machinery	50.1	1.6	5.8	23.5	0.1	6.7	1.3	12.1
Other Manufacturing	19.0	-9.1	-1.0	-2.8	1.0	0.3	3.4	26.2
Construction	-10.2	-2.7	-10.2	0.4	—	0.1	0.1	2.2
Trade	-12.7	-9.7	-0.4	2.0	-0.4	0.4	-0.1	-4.9
Finance	7.3	-2.7	-0.4	0.9	—	0.3	0.7	8.6
Public Services	-10.5	-10.5	—	0.1	-0.4	—	—	0.2
Others	-0.8	-11.0	-1.1	3.2	0.2	0.5	0.3	7.6
Total	0.0	-121.5	-9.6	45.0	4.4	9.8	17.7	60.7

Note: The annual growth rates of GDP, consumption, investment and exports, calculated from national accounts data for 1975 and 1985 at 1980 constant prices, are 7.7%, 5.8%, 11.2% and 13.0% respectively.

exports, also appears to support our view that the Korean economy was maturing.

Korean growth in the above two periods can be characterized by its rapidity and raised degree of maturity. Although we can find these characteristics in the post-war growth of Japan until the beginning of the 1970s, exports played a remarkable role in the case of Korea.

3.3. The Taiwanese Economy

The results for Taiwan in 1966-76 and 1976-84 are shown in Tables 8 and 9. We found several similarities with the Korean pattern of growth, which also characterize the growth of Asian NIEs.

3.3.(1) 1966-76

Table 8 indicates that manufacturing expansion was also observed in Taiwan. It accounted for 92.4% of the positive DPGs.

Like the case of Korea, the most significant source of positive DPGs was the deviation of exports, which expanded at a considerably rapid rate and benefited machinery, "other manufacturing" and chemicals, in particular. Although the change in input coefficients and the deviation of exports were also positive factors, the former being the second source of the expansion of the expansion of chemical and "other manufacturing" and the latter being significant for construction, their significance on the whole was inferior to that of exports.

The manufacturing DPGs explained by the deviation of exports amounts to 80.0% of the positive deviations. The export-led pattern of growth is quite obvious.

3.3(2) 1976-1984

In this period, there took place a change in the pattern of manufacturing expansion whereby "other manufacturing" decreased its share. However, as much as 86.3% of the positive DPGs was still attributable to the manufacturing sectors, as shown in Table 9.

A recession was also observed in Taiwan in this period. There was a considerable fall in the growth rates of exports and investment, of which the fall of the latter was more considerable. Investment became a negative source of DPGs.

In spite of the slowing down, exports could continue to be an outstanding cause of positive DPGs. The export-led pattern of growth was still obvious.

Table 8 DPG Decomposition for Taiwan, 1966-76

	DPG	Deviation of			Change in Coef.			
		C	If	E	M ^c	M ^l	M ^a	A
Agriculture, Forestry, & Fisheries	-50.1	-51.9	-0.7	-7.5	0.9	—	-12.4	20.0
Mining	-8.2	-1.7	0.7	-0.3	—	—	-1.8	-5.1
Chemicals	22.5	-6.7	0.9	18.2	-0.3	0.2	1.0	10.1
Metals	9.8	-1.2	2.7	5.1	-0.1	0.1	2.0	2.1
Machinery	26.5	0.5	4.9	29.0	0.1	0.8	-1.0	2.8
Other Manufacturing	33.6	-13.3	1.9	27.7	1.0	0.5	-0.5	15.6
Construction	5.5	-1.3	7.8	-1.5	-0.1	—	-0.1	0.7
Trade	-16.4	-7.7	-1.9	1.8	0.1	—	-0.2	-8.2
Finance	2.2	-1.6	—	1.4	-0.2	—	0.1	2.5
Others	-25.4	-31.4	0.3	2.7	-2.0	0.1	-2.7	7.7
Total	0.0	-116.3	16.7	66.5	-0.6	1.8	-15.5	48.1

Note: The annual growth rates of GDP, consumption, investment and exports, calculated from national accounts data for 1966 and 1976 at 1976 constant prices, are 9.8%, 7.6%, 15.0% and 20.2% respectively.

Table 9 DPG Decomposition for Taiwan, 1976-84

	DPG	Deviation of			Change in Coef.			
		C	I ^f	E	M ^c	M ^l	M ^A	A
Agriculture, Forestry, & Fisheries	-30.0	-8.3	-0.6	-7.6	-1.2	—	-6.2	-3.0
Mining	-12.4	-1.0	-1.7	0.8	—	0.1	-4.3	-5.5
Chemicals	12.0	-7.9	-5.0	14.8	-1.3	0.7	12.2	1.2
Metals	29.1	-0.1	-7.8	19.9	—	2.4	15.5	2.0
Machinery	45.2	5.2	-4.6	34.6	-0.8	5.5	2.2	2.8
Other Manufacturing	-15.7	-17.0	-7.8	9.0	-5.9	0.3	-2.1	12.5
Construction	-22.1	-0.9	-22.6	0.3	0.1	—	-0.2	1.3
Trade	8.1	2.9	-2.4	3.2	-1.0	0.4	1.7	4.4
Finance	-9.7	-9.6	-1.2	2.4	0.4	0.2	-2.8	1.1
Public Services	5.6	5.6	—	—	—	—	—	—
Others	-10.2	-8.8	-4.0	1.7	0.8	0.6	2.2	-1.0
Total	0.0	-39.9	-57.5	78.8	-8.8	10.1	18.2	15.9

Note: The annual growth rates of GDP, consumption, investment and exports, calculated from national accounts data for 1976 and 1984 at 1981 constant prices, are 8.1%, 6.8%, 6.0% and 11.5% respectively.

It seems that in Taiwan, as well as in Korea, the economy was maturing. Table 9 suggests that machinery, metals and chemicals increased their share in output, and in exports as well. Import substitution of intermediate and investment demand was also observed.

4. Concluding Remarks

We have presented a method to explain quantitatively the causes of observed change in the composition of industries. We have applied this method to the data of Japan for 1914-85, of Korea for 1963-84 and of Taiwan for 1966-84 to compare their patterns of growth. The result of our analysis can be summarized as follows:

1. Japanese growth in the pre-war period was characterized by the expansion of its manufacturing and construction sectors. The change in the pattern of intermediate demand, the growth of investment, and the import substitution supported that growth.
2. After the war, Japanese industrialization shifted its center of gravity to heavy industries, among which the machinery sector became outstanding in the later period. The growth of investment and exports, of which the latter was more conspicuous in the later period, played a significant part.
3. In the period after the mid-1960s, Japan enlarged its service sectors. Changes in the patterns of intermediate demand and consumption demand supported that enlargement.
4. Conspicuous in the Korean and Taiwanese economies was the expansion of their manufacturing sectors, for which expansion exports, and their export-oriented policy, played a remarkably significant role.
5. It seems that the economies of Korea and Taiwan were becoming more mature in the period after the mid-1970s. The growing exports of heavy manufactures, the import substitution of intermediate and investment goods, and strengthened interindustry linkages were suggested.

Appendix

A. Sources of Input-Output Tables

Japanese tables for 1914 and 1954: Chenery, Shishido, and Watanabe, 1962.

Other tables of Japan: Tables compiled by Management and Coordination Agency, et al.

Tables of Korea: Tables compiled by the Bank of Korea.

Tables of Taiwan: Tables compiled by Council for International Economic Cooperation and Development, Executive Yuan (tables for 1966), Council for Economic Planning and Development, Executive Yuan (tables for 1976), and Directorate-General of Budget, Accounting and Statistics, Executive Yuan (tables for 1984).

B. Sources of Price Indexes

Except for Japanese tables for 1914 and 1954 being expressed in 1951 constant yen, all the original tables are in current prices. We converted them into tables expressed in constant prices using wholesale price indexes by commodity, consumer price indexes by commodity, and GDP deflators and GNP deflators by product.

1. For the analysis of the Japanese economy, we prepared tables for 1955 and 1965 at 1965 yen level, tables for 1965 and 1975 at 1975 yen, and tables for 1975 and 1985 at 1985 yen. Price indexes were obtained from the following sources:

Bank of Japan. Statistics Department. *Price Indexes Annual*. 1970 ed.

_____. Research and Statistics Department. *Price Indexes Annual*. 1980 ed.

_____. Research and Statistics Department. *Commodities, Weights and Linked Indexes of 1985 Base Wholesale Price Indexes*. 1988.

Statistics Bureau of Prime Minister's Office. *On the Revision of Consumer Price Indexes*. 1965 ed.

_____. *Linked Indexes of 1975 Base Consumer Price Indexes*. 1976.

Management and Coordination Agency. Statistics Bureau. *Linked Indexes of 1985 Base Consumer Price Indexes*. 1987.

Economic Planning Agency. *Annual Report on National Income Statistics*. 1967 ed.

_____. *Annual Report on National Accounts*. 1985 ed. and 1988 ed.

2. We compiled Korean tables for 1963 and 1975 in 1970 constant prices and tables for 1975 and 1985 in 1980 prices. Price indexes were obtained from the following sources:

Bank of Korea. *Economic Statistics Yearbook*. 1976 ed., 1977 ed, and 1987 ed.

_____. *National Accounts*. 1987 ed.

3. For the analysis of the Taiwanese economy, we prepared tables for 1966 and 1976 at 1976 constant N.T. dollars and tables for 1976 and 1984 at 1980 N.T. dollars, using the price indexes obtained from the following sources:

Executive Yuan. Council for Economic Planning and Development. *Taiwan Statistical Data Book*. 1981 ed. and 1987 ed.

_____. Directorate-General of Budget, Accounting and Statistics. *Statistical Yearbook of the Republic of China*. 1988 ed.

_____. Directorate-General of Budget, Accounting and Statistics. *National Income of the Republic of China*. 1982 ed. and 1988 ed.

References

- [1] Aoki, Koji, and Yoshihisa Inada (1980), "Factor Analysis of Industrialization in Korea: A Comparison with the Japanese Pattern," *Ajia Keizai* Vol. 21, No. 5, pp.27-46 (in Japanese).
- [2] Chen Kuang-hui, and Kiyoshi Fujikawa (1987), "An Analysis of 'Deviation from Proportional Growth' of the Taiwanese Economy," *Sekai Keizai Hyoron* Aug, pp.53-65 (in Japanese).
- [3] Chen Kuang-hui, and Kiyoshi Fujikawa (1989), "A Note on DPG (Deviation from Proportional Growth) Analysis and the Patterns of Industrial Development in Japan and Taiwan," *I[n]ternational U[n]iversity of J[apan] Annual Review* Vol. 6, pp.125-44 (in Japanese).

- [4] Chenery, Hollis B (1960), "Patterns of Industrial Growth," *American Economic Review* Vol. 50, pp.624-54.
- [5] Chenery, Hollis B., Shuntaro Shishido, and Tsunehiko Watanabe (1962), "The Pattern of Japanese Growth, 1914-1954," *Econometrica* Vol. 30, pp.98-139.
- [6] Clark, Colin (1957), *The Condition of Economic Progress*, 3rd ed., London: Macmillan.
- [7] Han Bock-sang (1989), "Factor Analysis of Economic Growth and Industrial Change in Korea, 1973-83," *Ajia Keizai* Vol. 30 No. 7, pp.25-38 (in Japanese).
- [8] Hauthakker, H. S. (1957), "An International Comparison of Household Expenditure Pattern, Commemorating the Centenary of Engel's law," *Econometrica* Vol. 25, pp.532-51.
- [9] Kuznets, Simon (1966), *Modern Economic Growth: Rate, Structure and Spread*, New Haven: Yale UP.
- [10] Rao, C. Radhakrishna (1973), *Linear Statistical Inference and Its Application*, New York: Wiley.
- [11] Rostow, W. W. (1960), *The Stages of Economic Growth: A Non-Communist Manifesto*, London: Cambridge UP.
- [12] Watanabe, Tsunehiko, and Terukazu Suruga (1977), "Methods for Analyzing the Sources of Industrial Growth and Postwar Japan's Experience," *Osaka Economic Papers* [Osaka University] Vol. 26 No. 3-4, pp.154-66 (in Japanese).

Table A Sector Classification for Japan, 1914-54

1	Agriculture, Forestry, & Fisheries	Agriculture, Forestry, & Fisheries
2	Mining	Oil and Coal Other Mining
3	Chemicals	Chemicals Oil & Coal Products
4	Metals	Metals
5	Machinery	Machinery Transportation Machinery
6	Other Manufacturing	Food Products Fiber and Leather Wood Products Paper Products Printing & Publishing Rubber Products Non-Metallic Mineral Products Other Manufacturing
7	Construction	Construction
8	Trade	Trade
9	Others	Electric, Gas, & Water Supply Real Estate Transportation & Communication Services Others

Table B Sector Classification for Japan, 1955-65

1	Agriculture, Forestry, & Fisheries	Agriculture, Forestry, & Fisheries ^w
2	Mining	Mining ^w
3	Chemicals	Chemical Products ^w Oil & Coal Products ^w
4	Metals	Steel ^w Non-Ferrous Metals ^w Metal Products ^w
5	Machinery	Machinery ^w
6	Other Manufacturing	Food Products ^w Fiber Products ^w Wood Products ^w Paper Products ^w Non-Metallic Mineral Products ^w Other Manufacturing ^w
7	Construction	Construction ^c
8	Trade	Trade ⁿ
9	Others	Electric, Gas, & Water Supply ^c Transportation, Communication, & Warehousing ^c Real Estate ^c Others ⁿ

^wCorresponding index in wholesale price index was used as deflator.

^cCorresponding index in consumer price index was used as deflator.

ⁿGNP deflator was used to deflate its production.

Table C Sector Classification for Japan, 1965-75

1 Agriculture, Forestry, & Fisheries	Agriculture, Forestry, & Fisheries ^w
2 Mining	Mining ^w
3 Chemicals	Chemical Products ^w
	Oil & Coal Products ^w
4 Metals	Steel ^w
	Non-Ferrous Metals ^w
	Metal products ^w
5 Machinery	General Machinery & Precision Apparatus ^w
	Transportation Machinery ^w
6 Other Manufacturing	Food Products ^w
	Fiber Products ^w
	Wood Products ^w
	Paper Products ^w
	Non-Metallic Mineral Products ^w
	Other Manufacturing ^w
7 Construction	Construction ^c
8 Trade	Trade ^d
9 Finance	Banking & Insurance ^d
	Real Estate ^c
10 Public Services	Public Services ^d
11 Others	Electric, Gas, & Water Supply ^w
	Transportation, Communication, & Warehousing ^c
	Others ^d

^wCorresponding index in wholesale price index was used as deflator.

^cCorresponding index in consumer price index was used as deflator.

^dGDP deflator was used to deflate its production.

Table D Sector Classification for Japan, 1975-85

1 Agriculture, Forestry, & Fisheries	Agriculture, Forestry, & Fisheries ^w
2 Mining	Mining ^w
3 Chemicals	Chemical Products ^w
	Oil & Coal Products ^w
4 Metals	Steel ^w
	Non-Ferrous Metals ^w
	Metal Products ^w
5 Machinery	General Machinery ^w
	Electric Machinery ^w
	Transportation Machinery ^w
	Precision Apparatus ^w
6 Other Manufacturing	Food Products ^w
	Fiber Products ^w
	Wood Products ^w
	Paper Products ^w
	Non-Metallic Mineral Products ^w
	Other Manufacturing ^w
7 Construction	Construction ^c
8 Trade	Trade ^d
9 Finance	Banking & Insurance ^d
	Real Estate ^c
10 Public Services	Public Services ^d
11 Others	Electric, Gas, & Water Supply ^w
	Transportation, Communication, & Warehousing ^c
	Others ^d

^wCorresponding index in wholesale price index was used as deflator.

^cCorresponding index in consumer price index was used as deflator.

^dGDP deflator was used to deflate its production.

Table E Sector Classification for Korea, 1963-75

1 Agriculture, Forestry, & Fisheries	Agriculture (including Rice Milling) ^w Fishery ^w Forestry ^w
2 Mining	Mining ^w
3 Chemicals	Rubber Products ^w Chemical Products ^w Oil & Coal Products ^w
4 Metals	Metal Products ^w
5 Machinery	Machinery ^w
6 Other Manufacturing	Food Products ^w Beverage and Tobacco ^w Fibers ^w Textile Products ^w Leather Products ^w Wood Products ^w Paper Products ^w Printing & Publishing ^w Non-Metallic Mineral Products ^w Other Manufacturing ^w
7 Construction	Construction ⁿ
8 Trade	Trade ⁿ
9 Finance	Banking, Insurance, & Real Estate ⁿ
10 Others	Electric, Gas, & Water Supply ⁿ Transportation, Communication, & Warehousing ⁿ Others ⁿ

^wCorresponding index in wholesale price index was used as deflator.

ⁿGNP deflator was used to deflate its production.

Table F Sector Classification for Korea, 1975-85

1 Agriculture, Forestry, & Fisheries	Agriculture and Live Stock ^w Fisheries ^w Forestry ^w
2 Mining	Mining ^w
3 Chemicals	Rubber Products ^w Chemical Products ^w Oil & Coal Products ^w
4 Metals	Metal products ^w
5 Machinery	General Machinery ^w Electric Machinery ^w Transportation Machinery ^w Precision Apparatus ^w
6 Other Manufacturing	Food Products ^w Beverage ^w Tobacco ^w Fibers ^w Textile Products ^w Leather Products ^w Wood Products ^w Pulp & Paper Products ^w Printing & Publishing ^w Non-Metallic Mineral Products ^w Other Manufacturing ^w
7 Construction	Construction ^d
8 Trade, Restaurants & Hotels	Trade, Restaurants & Hotels ^d
9 Finance	Banking, Insurance, & Real Estate ^d
10 Public Services	Public Services ^d
11 Others	Electric, Gas, & Water Supply ^d Transportation, Communication, & Warehousing ^d Others ^d

^wCorresponding index in wholesale price index was used as deflator.

^dGDP deflator was used to deflate its production.

Table G Sector Classification for Taiwan, 1966-76

1	Agriculture, Forestry, & Fisheries	Agriculture (including Rice Milling) ^w Live Stock ^w Fisheries ^w Forestry ^w
2	Mining	Mining ^w
3	Chemicals	Rubber and Plastic Products ^w Chemical Products ^w
4	Metals	Metal Products ^w
5	Machinery	General Machinery & Precision Apparatus ^w Electric Machinery ^w Transportation Machinery ^w
6	Other Manufacturing	Food Products ^w Beverage & Tobacco ^w Textile Products ^w Leather Products ^w Wood Products ^w Paper Products ^w Non-Metallic Mineral Products ^w Other Manufacturing ^w
7	Construction	Construction ^d
8	Trade	Trade ^d
9	Finance	Banking & Insurance ^d
10	Others	Electric, Gas, & Water Supply ^w Transportation, Communication, & Warehousing ^d Others ^d

^wCorresponding index in wholesale price index was used as deflator.

^dGDP deflator was used to deflate its production.

Table H Sector Classification for Taiwan, 1976-84

1	Agriculture, Forestry, & Fisheries	Agriculture ^w Live Stock ^w Fishery ^w Forestry ^w
2	Mining	Mining ^w
3	Chemicals	Rubber & Plastic Products ^w Basic Chemical Products ^w Final Chemical Products ^w
4	Metals	Primary Metals ^w Metal Products ^w
5	Machinery	General Machinery ^w Electric Machinery ^w Transportation Machinery ^w Precision Apparatus ^w
6	Other Manufacturing	Food Products ^w Beverage & Tobacco ^w Textile Products ^w Leather Products ^w Wood Products ^w Paper Products ^w Non-Metallic Mineral Products ^w Other Manufacturing ^w
7	Construction	Construction ^d
8	Trade, Restaurants & Hotels	Trade, Restaurants and Hotels ^d
9	Finance	Banking, Insurance, & Real Estate ^d
10	Public Administration	Public Administration ^d
11	Others	Electric, Gas, & Water Supply ^d Transportation, Communication, & Warehousing ^d Others ^d

^wCorresponding index in wholesale price index was used as deflator.

^dGDP deflator was used to deflate its production.