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Structural Change and its Impact on Productivity in Japan, Korea, and Singapore (1970-2000)*

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Abstract

This paper examines the impact of structural change on productivity through a decomposition of aggregate manufacturing productivity growth in Korea, Singapore, and Japan over the period 1970-2000. First, the shift-share analysis is utilized to measure the impact of the allocation of labor among manufacturing industries on aggregate labor productivity. Next, the impact of the allocation of labor and capital on total factor productivity (TFP) growth is analyzed. The findings show weak support for the positive impact on aggregate productivity of reallocation of factor inputs for Japan and Korea, and a positive impact for Singapore.

I. Introduction

Over the last three decades, East Asian economies went through a remarkable industrial transformation. Korea, Singapore, and Taiwan, in particular, metamorphosed from producers of traditional light industry products to producers of heavy industry and technologically sophisticated products. Subsequently economists started to debate on the sources of economic growth in East Asia. A large number of economists have been discussing whether it was due to the accumulation of physical and human capital and virtual insignificance of technological change or assimilation of new technologies that these countries maintained rapid growth rates. However, as pointed out by van Ark and Timmer (2003), there is another dimension of industrial development in these countries: "...the recent debate on the sources of growth in Asia has neglected the underlying dynamics of changes in productivity growth within sectors and related to this, the shift of resources from low to high-productivity sectors."

The transformation in the industrial structure in East Asian countries came along with structural change, i.e. change in the composition of production and factor inputs (capital and labor) among industries. Structural changes coexisted with gains in manufacturing productivity. Some researchers recognizing such coexistence pointed to structural change as a cause of aggregate productivity growth (e.g. Kaldor 1963, 1966, Chenery et al 1986, and Syrquin 1995). Among these, Kaldor (1963, 1966) argues that there is often surplus labor in some industries in the manufacturing sector and labor supply in the manufacturing sector is elastic. He asserts that a major source of labor supply in

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manufacturing is the flow of labor from low-productivity to with high-productivity industries and associates aggregate labor productivity growth in manufacturing sector with labor shifts. He also argues that labor shifts across industries increase average manufacturing productivity due to two reasons. First, labor absorbing industry is growing with increasing returns. Second, in the industry that is losing labor, productivity level rises with the withdrawal of labor. Kaldor emphasizes increasing returns and externalities in manufacturing.

Harberger (1998) provides a further insight into productivity and structural change. He differentiates between what he calls a "mushroom-process" (i.e. innovative activities in a particular industry improve productivity and cause a shift of resources from relatively low-productivity activities to itself), and a "yeast-process" (i.e. gains in productivity spreads across industries).[1] Long-run growth is a mix of these two processes.

Most studies about industrial development in developing economies deal with structural change and productivity separately. However, productivity comparisons across countries with catching-up recently attracted attention of many researchers (see e.g. Choi 1990, Szirmai 1993, Wagner and van Ark 1996, and OECD 1996). It has been argued that the catch-up process of Asian economies stemmed from productivity growth of individual industries and the allocation of production factors from low-productivity industries to high-productivity industries (e.g., Pilat 1996 and van Ark 1996).There is a need to examine the impact of structural changes in the manufacturing sectors of East Asian economies on partial and total factor productivity.

In this study, I test the hypothesis that the shifts of production factors, i.e. structural change, have a positive effect on aggregate manufacturing productivity growth as supposed by Syrquin (1995). The study covers Japan, Korea, and Singapore, and the period of analysis spans the years from 1970 to 2000. The methodology is adopted from Timmer and Szirmai (2000).

The structure of the study is as follows. In the second section, trends in productivity and structural change are briefly presented. The third section presents data and their sources. In the fourth section, an analysis of labor productivity is carried out for three countries. The fifth section extends this analysis to total factor productivity. Finally, the sixth section concludes with a wrap-up.

II. Trends in Structural Change and Productivity

Manufacturing sector is divided into 15 industries in this study as listed in Table 1. The changing share of industries in manufacturing sector output and labor can be seen in Table 2. Output refers to real value-added at 1995 prices normalized by relevant producers' price indices. Table 2 reveals that the importance of transport vehicles and electrical and electronic machinery industries in terms of output share in Japan increased and that of basic machinery industries was maintained during the last 30 years. The corresponding industries are chemicals, basic machinery, electrical and electronic machinery, and transport equipment in Korea and chemicals and electrical and electronic machinery industries in Singapore. Oil refining and transport equipment industries declined dramatically over time in Singapore. Overall, production in the three economies shifted to high value-added industries.

Table 3 presents labor productivity growth rates for three periods. Labor productivity is measured as real value-added per employee and the periodization is different for each country. For Japan the periods are 1973-1984 (from oil shock to Plaza Accord that led to rapid appreciation of yen and a relocation of resources towards overseas production), 1985-1990 (bubble economy), and 1991-2000 (recession). The periods for Korea are 1971-1979 (heavy and chemical industrialization drive where the government undertook heavy investments nurture heavy and chemical industries), 1980-1988 (structural adjustment), and 1989-1996 (technological sophistication). For Singapore the periods are 1974-1979 (early post-oil-shock growth period), 1979-1985 (the period of corrective wage policy[2]), and 1986-1996 (emphasis on productivity and promotion of technology-intensive production).

Table 3 presents productivity growth rates of each industry in manufacturing sectors. Aggregate labor productivity growth was particularly very high during the bubble era (second period) in Japan and third period in Singapore due to high output growth and the technological sophistication period (third period) in Korea. Productivity growth in Japan slowed down drastically after the burst of the bubble in the early 1990s. Korea's labor productivity performance was the most impressive. Productivity growth differentials across industry groups in Korea, where only three industries experienced annual average productivity growth rates below 8 percent, are smaller in comparison to that of Japan and Singapore after 1980. Labor productivity growth rates in Singaporean manufacturing sector was influenced heavily by electrical and electronic machinery industry since it accounted for half of the total manufacturing value-added and one third of labor force. The data demonstrate that high-productivity industries are also fastest growing industries.

Table 1 Major industry groups

Industry	*Corresponding ISIC categories*	*Major industries included*
Food	3100, 311, 312, 3130, 3140	Food, beverages, and tobacco manufactures
Tex.	3200, 3210, 3220, 3230, 3240	Textiles, wearing apparel, leather and products, and footwear
Wood	3300, 3310, 3320	Wood, wood products, furniture, and fixtures
Pap.	3400, 3410, 3420	Paper, paper products, printing, and publishing
Chem.	3500, 3510, 3520, 3521, 3522, 3523, 2529	Industrial chemicals and other chemical products
Pet.	3530, 3540	Petroleum, petroleum refineries, coal products
Plas.	3550, 3560	Rubber and plastic products
Min.	3600, 3610, 3620, 3690	Non-metallic minerals, pottery, glass products
Bas.met.	3700, 3710, 3720	Basic metals, iron and steel, non-ferrous metals
Met.pr.	3800, 3810	Fabricated metal products (except machinery and equipment)
Mach.	3820, 3821, 3822, 3823, 3824, 3829	Non electrical (basic) machinery and equipment
Elec.	3825, 3830, 3831, 3832, 3833, 3839	Electrical appliances, electronic machinery, office equipment
Tran.	3840, 3841, 3842, 3843, 3844, 3845, 3849	Transport equipment (transport vehicles, shipbuilding and repair, etc.)
Prec.	3850	Professional equipment, optical equipment, precision equipment
Others	3900	Other manufacturing

III. Description and Sources of Data

Output: Output refers to value-added at 1995 prices. Value-added data are obtained from the *Census of Manufactures* (*Kougyou Toukeihyou*) for Japan, *Yearbook of Statistics* for Singapore, and *Major Statistics of Korean Economy* and the *Report on Mining and Manufacturing Survey (Whole Country)* for Korea. Value-added data are deflated by producer's price indexes obtained from Korea Statistical Yearbook, Singapore Yearbook of Statistics, and the *Long-term Data Series* of the Bank of Japan.

Labor: To calculate labor productivity, value-added figures are divided to total number of employees. Employment data are obtained from various issues of industrial census for Japan, Singapore Yearbook of Statistics, and Major Economic Statistics of Korean Economy. Labor input employed in total factor productivity (TFP) refers to total hours worked. These are calculated by multiplying monthly working hours data by the factor 12 to obtain annual working hours per employee, and then multiplying by number of workers. These data take into account only the actual working hours of the employees, including overtime but excluding recess. The sources for the actual working hours data are the *Annual Report on the Monthly Labor Survey - National Survey* for Japan, *Yearbook of Labor Statistics* for Korea, and the *ILO Yearbook of Labor Statistics* for Singapore.

To calculate labor shares for TFP, workers' remuneration data are obtained from the Census of Manufactures for Japan, Yearbook of Labor Statistics for Korea, and the ILO Yearbook of Labor Statistics for Singapore. These data include all payments made to employees including benefits. Total remuneration per employee is multiplied by number of workers and divided to value-added to calculate labor share in output. Subtracting this from unity, the share of capital is obtained.

Capital: In this study, tangible and reproducible assets, i.e. nonresidential buildings and structures, plant, and equipments including office equipment, are included as part of the capital stock. Land, consumer durables, residential buildings and structures, and inventories, however, are excluded. To calculate capital stock, rather than depending on financial statement statistics, the cumulation technique named perpetual inventory method (PIM) is used, since the figures in the balance sheets generally do not reflect the economic value of capital stock adequately since the book values recorded in the balance sheets are largely influenced by tax considerations. The basic formula for the computation of capital stock in this method is given as follows:

$$K_t = K_{t-1} + I_t - D_t \qquad (1)$$

K_t refers to the estimated level of capital stock at the end of the period t, K_{t-1} to that of the previous period, I_t to addition to gross capital stock (investment), and D_t to capital consumption allowance. Three types capital assets are specified in estimations: (i) building and construction, (ii) plant and equipment, and (iii) transport equipment and others. It is assumed that the asset lives for each type of asset are asset-wise the same across countries. The data on capital stock span enough

Table 2 Shares of industries in manufacturing real value-added and labor

	Japan			Korea			Singapore		
Output	*1973-1984*	*1985-1990*	*1991-2000*	*1971-79*	*1980-1988*	*1989-1996*	*1974-1978*	*1979-1985*	*1986-1996*
Food	12.2	10.8	10.5	18.0	14.7	10.2	6.1	5.8	3.2
Tex.	6.6	5.3	3.9	21.7	19.1	12.5	4.7	4.2	1.6
Wood	4.8	3.4	2.6	5.3	2.4	1.2	4.0	2.6	0.6
Pap.	8.9	8.6	8.6	4.3	5.2	5.3	5.3	6.8	6.3
Chem.	8.2	9.5	10.0	8.0	8.3	9.5	4.5	9.3	11.5
Pet.	1.6	0.9	0.9	9.8	2.8	3.3	7.9	5.0	5.4
Plas.	4.2	4.8	5.0	5.4	4.6	4.4	3.6	3.2	2.8
Min.	4.8	4.5	4.2	6.2	4.7	4.9	2.9	2.9	1.9
Bas.met	8.6	5.7	4.8	5.7	7.7	7.0	1.8	1.4	0.7
Met.pr.	7.4	7.3	6.5	2.3	4.2	4.7	7.7	7.9	6.0
Mach.	11.2	11.4	10.8	1.9	4.4	7.5	12.5	8.2	6.2
Elec.	8.3	14.0	17.7	5.9	11.4	15.8	17.3	27.2	43.6
Tran.	9.0	10.0	10.9	3.3	7.0	10.1	17.8	11.0	6.8
Prec.	1.8	1.9	1.6	0.5	1.0	1.0	1.9	1.9	2.3
Others	2.3	2.0	1.8	1.7	2.4	2.5	2.1	2.6	1.3
Labor	Japan			Korea			Singapore		
Food	10.4	11.0	12.3	11.4	8.5	7.2	5.8	5.0	4.5
Tex.	13.3	11.1	8.7	35.0	30.4	22.1	16.2	13.2	8.4
Wood	6.2	4.5	4.0	0.8	1.1	1.8	5.9	5.1	1.8
Pap.	7.2	7.4	7.9	5.1	4.6	5.2	5.8	6.1	6.3
Chem.	3.9	3.6	3.8	5.2	4.4	5.0	2.3	2.5	3.1
Pet.	0.4	0.3	0.3	1.2	0.7	0.6	1.5	1.3	1.0
Plas.	4.4	5.3	5.8	4.8	5.9	5.1	4.6	4.3	4.8
Min.	4.8	4.2	4.1	4.8	4.8	4.6	2.2	2.3	1.8
Bas.met	5.9	4.7	4.2	3.6	4.3	4.1	0.9	0.8	0.7
Met.pr.	7.4	7.4	7.8	4.2	4.7	5.7	5.5	7.2	8.3
Mach.	9.9	10.4	10.9	3.5	5.1	9.1	6.7	7.3	8.1
Elec.	12.7	17.2	17.1	9.4	12.8	15.0	24.3	30.6	37.4
Tran.	8.4	8.4	9.0	4.6	6.9	9.3	12.5	9.7	8.6
Prec.	2.4	2.3	2.0	1.2	1.6	1.6	3.6	2.4	2.4
Others	2.7	2.3	2.1	5.3	4.2	3.8	2.1	2.1	2.8

Source: Author's calculations

number of years in order to cover the asset life of the longest-life asset.

In order to estimate capital stock, we need to calculate the capital stock for a benchmark year and then extend the series by adding net investment data using the equation (1). The benchmark years are selected as 1955 for Japan, 1968 for Korea and 1970 for Singapore. For Korea and Japan, the benchmark years refer to years of national wealth surveys. For Singapore, a decomposition of gross fixed capital formation was not available. Hence, the method applied by Hsieh (1997) is employed to specify the benchmark value of the capital stock: initial value of investment is divided to the sum of

Table 3 Labor productivity growth rates

	Japan				Korea				Singapore			
	1973-1984	*1985-1990*	*1991-2000*	*Overall*	*1971-1979*	*1980-1988*	*1989-1996*	*Overall*	*1974-1978*	*1979-1985*	*1986-1996*	*Overall*
Total	3.6	4.7	2.4	3.6	5.3	8.0	12.2	8.8	2.0	3.1	4.6	3.6
Food	2.5	2.3	0.5	2.7	10.1	6.2	11.3	8.9	3.5	1.5	0.0	2.6
Tex.	4.5	3.5	1.3	3.7	0.3	3.1	-0.1	1.4	7.8	3.1	0.3	5.8
Wood	4.7	2.6	0.2	3.1	8.0	8.1	9.6	8.5	12.1	3.7	3.8	3.4
Pap.	2.7	4.5	1.4	3.1	9.9	8.8	11.7	10.3	2.9	8.3	4.2	5.4
Chem.	3.1	6.9	1.7	4.0	-10.0	7.1	10.0	4.3	8.2	4.3	2.0	7.9
Pet.	-4.2	0.9	-3.5	-0.6	-2.7	8.7	10.6	5.4	-4.5	-14.3	6.2	0.6
Plas.	2.4	4.0	1.4	3.1	5.9	6.7	11.8	9.1	1.5	2.4	0.5	2.5
Min.	3.3	4.5	1.4	4.2	8.7	8.8	11.2	10.4	6.3	-1.2	6.3	4.9
Bas.met.	2.1	4.8	11.1	5.5	13.6	13.1	7.5	9.6	-2.8	-3.4	-3.1	0.3
Met.pr.	2.4	4.2	0.3	3.0	16.6	10.0	11.3	12.6	3.3	-1.7	-1.2	2.9
Mach.	4.5	3.9	-0.2	3.2	10.5	11.1	17.5	11.8	-1.0	4.4	3.1	1.8
Elec.	6.8	7.5	5.0	7.1	9.3	9.6	13.3	11.3	8.2	4.5	8.3	11.3
Tran.	5.5	5.7	1.3	4.9	15.1	9.9	9.9	11.7	3.1	1.9	-3.9	2.0
Prec.	6.8	2.4	2.5	5.3	21.9	9.1	9.1	13.5	9.2	12.3	4.2	8.8
Others	4.2	3.9	1.1	3.4	5.3	7.9	7.9	8.6	6.6	17.2	-0.4	3.8

Source: Author's calculations

the capital consumption allowance ratio and the growth rate of investment for the first seven years of the series that start from 1963. This is based on the assumption that the investment before the initial year of the benchmark year capital stock grows at a constant rate.

Finally, the formula to calculate the capital stock takes the following form:

$$K_t = K_{t-1} + \sum_{i=1}^{3}(1-\delta_i)\Delta K_{i,t-1} \quad (2)$$

where δ_i refers to capital consumption allowance ratio for each type of asset *i*. The data for fixed assets used in the calculation of capital stock are compiled from the Census of Manufactures for Japan and Report on Mining and Manufacturing Survey for Korea. Price indexes of investment goods are important in capital stock calculations. The deflators for each type of capital assets are calculated from national income accounts for Japan and Korea (available in *Annual Report on National Accounts* for Japan, and Korea Statistical Yearbook).

Finally, capital consumption allowance rates are adopted from Jorgenson and Sullivan (1981) as 0.0361 for buildings and constructions, 0.1047 for machinery and equipment, and 0.2935 for transport equipment. For Singapore, a decomposition of the gross capital formation was not available and therefore, a simple average of these four rates (0.1448) was used.

IV. The Impact of Structural Change on Labor Productivity

1. Methodology

To measure the contribution of structural change (resource reallocation among sectors) to the growth of productivity, the shift-share method can be used. The shift-share methodology in this study is adopted from Timmer and Szirmai (2000). This method has recently been used extensively to analyze the impact of structural change on labor productivity for a number of countries (e.g. Fagerberg 2000, Timmer and Szirmai 2000, Jalava et al 2002, and van Ark and Timmer 2003). In this section, aggregate labor productivity growth in the manufacturing sector will be decomposed. As a staring point, labor productivity is defined as:

$$PL_{m,t} = \frac{Q_{m,t}}{L_{m,t}} = \sum_{i=1}^{15} \frac{Q_{i,t}}{L_{i,t}} \cdot \frac{L_{i,t}}{L_{m,t}} \tag{3}$$

where PL, L, Q, and the subscripts refer to aggregate labor productivity, employment, and output. The subscripts t, i ($i=1,2,3,\ldots,15$), and m denote time, specific industry i, manufacturing aggregate, respectively. Renaming the term $L_{i,t}/L_{m,t}$ (labor share of industry i) and $Q_{i,t}/L_{i,t}$ (labor productivity of industry i) as $sl_{i,t}$ and $PL_{i,t}$, respectively, we can rewrite (3) as a weighted sum for industries:

$$PL_{m,t} = \sum_{i=1}^{15} PL_{i,t} \cdot sl_{i,t} \tag{4}$$

Next, define the changes in labor productivity in any time period $[0,1]$, where 0 and 1 stand for the beginning and the end of the period, respectively. The change in labor productivity level can be written simply by subtracting the level of labor productivity at year 1 from that of 0:

$$PL_{m,1} - PL_{m,0} = \sum_{i=1}^{15} PL_{i,1} \cdot sl_{i,1} - \sum_{i=1}^{15} PL_{i,0} \cdot sl_{i,0} \tag{5}$$

Finally, with some mathematical manipulations the decomposition takes the following shape:

$$PL_{m,1} - PL_{m,0} = \sum_{i=1}^{15} \left(PL_{i,1} - PL_{i,0}\right) \cdot sl_{i,0} + \sum_{i=1}^{15} \left(sl_{i,1} - sl_{i,0}\right) \cdot PL_{i,0} + \sum_{i=1}^{15} \left(sl_{i,1} - sl_{i,0}\right) \cdot \left(PL_{i,1} - PL_{i,0}\right) \tag{6}$$

Dividing each side by $PL_{m,0}$, one can rearrange the equation in growth terms. The first term on the right-hand side of equation (6) describes productivity growth within individual industries and measures “intra-industry productivity growth”. The second term measures labor shift based on the labor productivity level at the beginning of the period. When employment shares of individual industries that initially have high productivity levels increase, there is a reallocation of labor towards industries with rapid productivity growth. Following Timmer and Szirmai (2000) I name this the “static shift effect.” The third term measures the cross-effects of the changes in both labor productivity and labor shares, i.e. a reallocation of labor towards industries with rapid growth in productivity. Since it takes into account both labor productivity and labor share changes in the selected period, I name this term the “dynamic shift effect,” following Timmer and Szirmai. Two shift effects measure the impact of structural change on aggregate manufacturing labor productivity. If their sum is positive, structural change has a positive impact on labor productivity.

2. Findings.

Table 4 presents results at the aggregate level and Table 5 at the industry level. The results reveal

Table 4 Shift-share analysis of productivity growth

	Sources of productivity growth	*Overall*[a]	*Period 1*[b]	*Period 2*[b]	*Period 3*[b]
Japan	Productivity growth	3.6	3.6	4.7	2.4
	Intra-industry productivity	107.5	99.7	104.0	118.9
	Static shift effects	-5.9	0.5	-2.2	-15.8
	Dynamic shift effects	-1.6	-0.2	-1.7	-3.1
Korea	Productivity growth	5.3	8.0	12.2	8.8
	Intra-industry productivity	106.2	120.6	100.3	96.7
	Static shift effects	-1.7	-11.2	1.9	4.8
	Dynamic shift effects	-4.5	-9.4	-2.2	-1.5
Singapore	Productivity growth	3.6	2.0	3.1	4.6
	Intra-industry productivity	97.3	149.8	82.2	83.1
	Static shift effects	7.7	-38.6	19.1	21.4
	Dynamic shift effects	-5.0	-11.2	-1.3	-4.6

Notes: [a] 1973-2000 for Japan, 1974-1996 for Singapore, and 1971-1996 for Korea.
[b] The periods for each country are as explained in the text (Section II).
Source: Author's calculations

Table 5 The impact of labor shifts on aggregate manufacturing labor productivity

JAPAN												
	Intra-industry effect				Static shift effect				Dynamic shift effect			
	1973-1984	*1985-1990*	*1991-2000*	*1973-2000*	*1973-1984*	*1985-1990*	*1991-2000*	*1973-2000*	*1973-1984*	*1985-1990*	*1991-2000*	*1973-2000*
Food	8.6	5.7	3.4	6.2	1.2	-15.2	-13.1	-5.7	0.0	-0.3	0.0	0.0
Tex.	6.4	4.1	3.2	4.7	-3.5	15.8	9.2	5.5	-0.2	0.3	0.0	-0.1
Wood	4.8	2.2	1.1	2.9	-3.8	13.1	2.5	3.2	-0.3	0.3	0.0	-0.1
Pap.	6.2	7.8	6.2	6.8	0.3	-11.2	-4.5	-2.1	0.1	-0.4	0.0	0.0
Chem.	8.8	12.5	8.0	9.9	-1.1	9.7	-6.5	-1.5	-0.4	0.4	0.0	-0.1
Pet.	-0.6	0.1	-0.1	-0.2	0.2	7.1	-0.1	0.1	-0.2	0.5	0.0	0.0
Plas.	2.7	4.1	3.3	3.3	2.0	-18.7	-3.8	-2.9	0.1	-0.5	0.0	0.0
Min.	4.2	4.5	3.9	4.3	-1.2	12.3	0.4	1.2	-0.1	0.4	0.0	0.0
Bas.met.	8.0	7.3	24.5	12.3	-2.7	37.4	11.8	6.7	-0.2	1.9	-3.5	-1.9
Met.pr.	5.7	7.6	0.5	5.1	-1.2	-21.9	-1.6	-0.8	0.0	-0.6	0.2	0.1
Mach.	12.9	10.5	0.5	8.8	0.8	-29.3	-4.5	-3.0	0.1	-2.2	0.1	0.2
Elec.	14.0	20.9	55.1	27.8	8.8	-18.7	-1.2	-5.3	0.8	-0.8	0.1	0.3
Tran.	13.1	13.5	5.6	11.3	1.2	5.9	-6.5	-2.7	0.1	-1.4	0.0	0.1
Prec.	3.0	1.4	2.3	2.3	0.3	5.6	1.3	0.5	0.1	0.1	0.0	0.0
Others	2.3	2.0	1.5	1.9	-0.9	5.7	0.7	0.9	0.0	0.3	0.0	0.0
Total	99.7	104.0	118.9	107.5	0.5	-2.2	-15.8	-5.9	-0.2	-1.7	-3.1	-1.6

KOREA												
	Intra-industry shift effect				Static shift effect				Dynamic shift effect			
	1971-1979	*1980-1988*	*1989-1996*	*1971-1996*	*1971-1979*	*1980-1988*	*1989-1996*	*1971-1996*	*1971-1979*	*1980-1988*	*1989-1996*	*1971-1996*
Food	22.8	13.3	7.7	9.5	-1.2	22.0	-0.3	-3.3	-1.2	-1.2	-0.5	-0.3
Tex.	27.4	19.7	12.2	13.9	-0.4	30.2	-1.9	-7.9	0.3	-0.4	-2.0	-0.3
Wood	3.4	-0.8	-0.1	0.2	-0.1	-10.4	0.1	0.8	-1.1	-1.5	-0.3	-0.3
Pap.	5.5	6.4	4.1	4.4	-0.1	1.0	0.3	0.8	-0.2	-0.3	0.3	0.0
Chem.	12.1	10.6	9.3	9.1	-0.4	2.4	0.4	0.6	-0.3	-1.4	0.5	0.0
Pet.	-4.9	6.2	2.8	2.4	-1.4	1.5	-0.1	-1.8	-1.5	-5.7	-0.8	-0.6
Plas.	3.5	5.5	4.1	4.0	0.1	-8.2	-0.3	-0.2	-0.9	-0.5	-0.1	-0.2
Min.	5.7	5.4	5.0	4.8	0.0	5.7	-0.1	-0.6	-0.1	-3.0	-0.1	-0.2
Bas.met.	7.2	8.8	6.6	6.6	0.5	5.9	-0.1	0.0	0.0	-1.3	0.0	0.0
Met.pr.	3.6	8.0	3.8	4.2	0.1	0.6	0.8	2.5	0.1	-0.4	0.1	0.0
Mach.	4.0	6.5	7.0	6.2	0.3	-13.8	1.1	4.3	0.2	1.6	1.1	0.3
Elec.	7.0	16.0	24.1	19.3	1.0	-37.2	0.2	3.5	0.3	3.6	0.8	0.3
Tran.	3.2	9.9	10.1	8.6	0.4	-8.5	1.6	5.9	0.2	0.8	1.9	0.4
Prec.	1.1	1.7	0.9	1.0	0.0	-2.2	-0.1	0.0	0.0	0.3	-0.1	0.0
Others	4.5	3.7	2.5	2.7	-0.3	-0.4	0.2	0.3	-0.4	0.1	-3.1	-0.6
Total	106.2	120.6	100.3	96.7	-1.7	-11.2	1.9	4.8	-4.5	-9.4	-2.2	-1.5
SINGAPORE												
	Intra-industry shift effect				Static shift effect				Dynamic shift effect			
	1974-1978	*1979-1985*	*1986-1996*	*1974-1996*	*1974-1978*	*1979-1985*	*1986-1996*	*1974-1996*	*1974-1978*	*1979-1985*	*1986-1996*	*1974-1996*
Food	6.3	10.0	2.4	3.7	1.5	-0.1	0.1	-0.6	-0.2	0.1	-0.2	-0.6
Tex.	9.1	10.3	-0.2	2.3	0.2	7.1	-3.5	-4.7	0.3	-0.2	0.0	0.0
Wood	11.3	1.8	4.9	4.2	0.1	8.5	-2.9	-4.2	-0.5	-0.2	-0.2	-0.8
Pap.	4.4	11.4	4.4	5.0	-0.1	-6.3	0.0	0.9	0.0	0.3	0.0	0.0
Chem.	5.7	22.9	3.6	6.6	0.5	-14.4	4.7	6.6	-0.1	0.4	0.0	0.0
Pet.	-29.7	0.4	5.0	1.2	3.0	-5.5	-1.8	-2.6	-2.6	-0.9	0.0	-0.2
Plas.	6.2	1.6	0.4	1.0	0.0	3.5	1.6	1.3	0.0	-0.2	0.0	0.0
Min.	6.2	-1.5	1.6	1.2	1.4	-13.2	-0.6	0.3	-0.3	0.6	0.0	0.0
Bas.met.	-1.3	2.1	-0.2	0.1	0.5	1.1	-0.3	-0.7	0.3	-0.4	0.0	0.0
Met.pr.	7.3	15.1	-1.0	2.5	-1.0	-6.0	4.0	5.5	0.1	-4.3	0.0	-0.2
Mach.	4.3	-1.6	2.5	1.5	-2.5	-25.0	1.4	5.9	-1.1	-2.5	0.0	-0.2
Elec.	27.9	53.9	54.0	44.5	-3.8	-14.3	5.6	9.5	0.9	4.0	0.0	0.0
Tran.	32.3	14.5	3.5	6.8	7.9	24.9	9.7	3.3	-1.2	-5.0	-0.7	-2.3
Prec.	4.0	4.0	1.6	1.9	0.2	4.2	0.3	-0.3	-0.6	-0.7	0.0	-0.1
Others	3.1	4.5	-0.2	0.8	-0.2	-3.1	0.8	1.3	-0.1	-2.2	0.0	-0.2
Total	97.3	149.8	82.2	83.1	7.7	-38.6	19.1	21.4	-5.0	-11.2	-1.3	-4.6

Source: Author's calculations

that reallocation of labor across manufacturing industries was not important in explaining labor productivity gains for the past three decades in manufacturing sectors, accounting for small portions of labor productivity growth (3 percent in Singapore, and minus 6-7 percent in Japan and Korea).

In Japan, labor productivity growth resulted almost entirely from intra-industry productivity growth during the first two periods (1971-1990), while shift effects summed to about minus 20 percent of the productivity growth during the 1990s recession, i.e. there was a shift of labor towards industries with lower productivity. This finding points to restructuring of Japanese manufacturers in the form of release of labor from productive industries that struggle in an era of recession. Positive shift effects related to some industries such as basic metals are more than offset by especially electrical and electronic machinery, food, basic machinery, and transport equipment industries.

During the heavy and chemical industrialization (HCI) drive of the 1970s in Korea, the impact of labor shifts across industries on aggregate labor productivity growth was minus 20 percent. In the following two periods aggregate labor productivity growth resulted almost entirely from intra-industry effect. For the overall period, labor shifts worked against aggregate labor productivity. Positive shift effects result mainly from basic and electrical machinery and transport equipment industries whereas negative shift effects result mainly from textiles and food industries.

Finally in Singapore, the impact of labor shifts is minimal for the whole period, butt the results of the decomposition for the period after the reconstruction in 1979 comply with the standard arguments of structural change. However, intra-industry effect was the most important of the three effects. Labor shifts were relatively important as a source of aggregate manufacturing labor productivity growth after 1979; the impact on aggregate labor productivity was slightly below 20 percent. The importance of the electrical machinery and chemical industries is obvious from their shift effects.

These findings beg for interpretation. Manufacturing industries are generally exposed to competition via free trade and this stimulates restructuring to enhance international competitiveness through gains in productivity. We can expect negative shift effects throughout the restructuring process because some labor may be released[3] from more productive industries to less productive industries or domestic-oriented industries or sectors of the economy (such as services) that are (e.g. paper, textiles, minerals, wood, plastic, and food industries) which are not exposed to international competition. This may result in a revival of the employment share of domestic-oriented industries and thus result in negative shift effects. This seems to be valid for Japan (see from Table 2 that labor shares of paper, plastic, and food industries increased in the second and third periods where there were negative shift effects) and Korea (see from the same table that labor shares of wood and plastic industries increased in the first and second periods where there were negative shift effects).

The contributions of shift effects to overall productivity can also be partly explained by the existence of tight labor markets in the three countries. Labor markets were tight in Japan and Singapore for almost all periods. Tight labor market in Korea is rather a recent phenomenon that coexisted with technological sophistication (third period). In the case of a tight labor market, the workers shifting from low to high-productivity industries may not possess the necessary skills, which create a problem of mismatch, or workers may be reluctant to change jobs. This translates into negative shift effects and hence, labor shifts run against aggregate productivity gains. The responses of the governments to the tight labor market situation are important at this point. The governments of Korea (after 1980) and Japan stood relatively neutral whereas the government of Singapore opted for distorting the labor market[4] and actively engaging in upgrading and improving the skills of labor. Singapore government placed a strong emphasis on higher value-added generation via skill upgrading and further automation. The positive shift effects in Singapore after 1979 reflect these efforts. The negative shift effects in Japan and in Korea reflect the neutrality of the governments.

Table 6 TFP growth and reallocation effects

Unit: %	Period	TFP growth rate	Intra-industry effect	Capital reallocation effect	Labor reallocation effect	Total reallocation Effect
Japan	1973-84	1.7	94.8	2.4	2.8	5.2
	1985-90	3.9	93.6	4.5	2.0	6.5
	1991-2000	1.6	112.1	-8.4	-3.7	-12.1
	1973-2000	3.0	100.7	-1.0	0.3	-0.7
Korea	1971-79	6.2	94.1	9.5	-3.6	5.9
	1980-88	3.1	113.4	1.7	-15.1	-13.4
	1989-94	4.2	106.7	1.2	-8.0	-6.7
	1971-94	4.3	112.3	10.5	-22.7	-12.3
Singapore	1975-78	1.1	78.7	47.7	-26.4	21.3
	1979-85	-4.7	83.2	17.3	-0.4	16.9
	1986-96	2.3	72.0	15.9	12.2	28.1
	1975-96	1.6	77.0	22.4	0.6	23.0

Source: Author's calculations

V. Structural Change and Total Factor Productivity: A Decomposition Analysis

1. Decomposition of Total Factor Productivity (TFP)

In this section a multi-factor approach using total factor productivity (TFP) is introduced. To estimate TFP, a Cobb-Douglas production function with constant returns to scale is assumed and TFP growth is calculated as a residual after deducting from output growth rate the factor input growth rates weighted by relevant share coefficients:

$$\frac{\Delta Q_i}{Q_i} = \frac{\Delta T_i}{T_i} + \omega_{Ki}\frac{\Delta K_i}{K_i} + \omega_{Li}\frac{\Delta L_i}{L_i} \qquad (7)$$

where Q_i, K_i and $L_i T$, ω_{Ki}, ω_{Li}, and the subscript t refer to output, capital stock, labor, total factor productivity, output share of capital, output share of labor, and time, respectively. The operator Δ stands for change between two points in time. In TFP estimations, the relevant measure for labor input used is not total number of workers used in labor productivity analysis. Instead, total working hours are used.

The results of TFP growth estimations are presented in the second column of Table 6. TFP growth rates for Japan, Korea, and Singapore are calculated to be 3.0 percent, 4.3 percent, and 1.6 percent, respectively. TFP growth rate in Japan is higher in the 1980s but very low for the "lost-decade" of the 1990s. Aggregate TFP growth rate in Singapore is the lowest.

In the three countries, there are shifts of resources from sectors such as food, textiles, and basic metals to industries such as basic machinery, electric machinery, and transport equipment. With resource reallocations from less efficient (i.e. with low TFP growth rates) sectors to more efficient sectors, aggregate TFP may be expected to grow. The portion of TFP growth not resulting from technical changes within industries was named "inter-industry technical change" by Massell (1961). Timmer and Szirmai (2000) distinguish it from "intra-industry technical change" as measured by sectoral TFP growth rates. In other words, the difference between aggregate TFP growth and output-weighted sectoral TFP growth is referred to as the "reallocation effect". Syrquin (1995) notes that positive reallocation effects point to efficiency improvement. This is due to the fact that resources are moving from sectors with low marginal productivity to those with higher marginal productivity.

To formulate reallocation effects, we start by formulating TFP growth rate for the industry (*i*) and the entire manufacturing sector (*m*):

$$\frac{\Delta T_m}{T_m} = \frac{\Delta Q_m}{Q_m} - \omega_{Km}\frac{\Delta K_m}{K_m} - \omega_{Lm}\frac{\Delta L_m}{L_m} \quad \text{and} \quad \frac{\Delta T_i}{T_i} = \frac{\Delta Q_i}{Q_i} - \omega_{Ki}\frac{\Delta K_i}{K_i} - \omega_{Li}\frac{\Delta L_i}{L_i} \tag{8}$$

In (8), factor shares in output sum up to unity, i.e. $\omega_K + \omega_L = 1$. Note that there are some restrictions. Aggregate output, aggregate capital, and aggregate labor inputs are the summations of the relevant values at the industry level, i.e. $Q_m = \sum_{i=1}^{15} Q_i$, $K_m = \sum_{i=1}^{15} K_i$, $L_m = \sum_{i=1}^{15} L_i$. Then, the following restrictions hold: $\Delta Q_m = \sum_{i=1}^{15} \Delta Q_i$, $\Delta K_m = \sum_{i=1}^{15} \Delta K_i$, and $\Delta L_m = \sum_{i=1}^{15} \Delta L_i$.[5] Next, we define capital and labor shares of each industry in total, k_i and l_i, where $k_i = K_i / K_m$ and $l_i = L_i / L_m$. Taking time derivatives of k_i and dividing by k_i we get:

$$\frac{dk_i}{dt}\frac{1}{k_i} = \frac{dK_i}{dt}\frac{1}{K_i} - \frac{dK_m}{dt}\frac{1}{K_m}, \text{ or, } \frac{\Delta k_i}{k_i} = \frac{\Delta K_i}{K_i} - \frac{\Delta K_m}{K_m}.$$

Rearranging,

$$\frac{\Delta K_i}{K_i} = \frac{\Delta k_i}{k_i} + \frac{\Delta K_m}{K_m} \tag{9}$$

Similarly for l_i,

$$\frac{\Delta L_i}{L_i} = \frac{\Delta l_i}{l_i} + \frac{\Delta L_m}{L_m} \tag{10}$$

Next, we turn to ΔQ_m. Since $\Delta Q_m = \sum_{i=1}^{15} \Delta Q_i$,

$$\frac{\Delta Q_m}{Q_m} = \sum_{i=1}^{15} \frac{\Delta Q_i}{Q_m} = \sum_{i=1}^{15} \frac{\Delta Q_i}{Q_i} \frac{Q_i}{Q_m} \tag{11}$$

Denoting output share (Q_i / Q_m) of each industry by ε_i and substituting (7), (9), and (10) into (11):

$$\frac{\Delta Q_m}{Q_m} = \sum_{i=1}^{15} \varepsilon_i \left[\frac{\Delta T_i}{T_i} + \omega_{Ki} \left(\frac{\Delta K_m}{K_m} + \frac{\Delta k_i}{k_i} \right) + \left(1 - \omega_{Ki}\right) \left(\frac{\Delta L_m}{L_m} + \frac{\Delta l_i}{l_i} \right) \right] \tag{12}$$

Since $\sum_{i=1}^{15} \omega_{Ki} \frac{Q_i}{Q_m} = \omega_{Km}$ and $\sum_{i=1}^{15} \left(1 - \omega_{Ki}\right) \frac{Q_i}{Q_m} = \omega L_m = 1 - \omega_{Ki}$,we get:

$$\frac{\Delta Q_m}{Q_m} - \omega_{Km} \frac{\Delta K_m}{K_m} - \left(1 - \omega_{Km}\right) \frac{\Delta L_m}{L_m} = \sum_{i=1}^{15} \varepsilon_i \left(\frac{\Delta T_i}{T_i} + \omega_{Ki} \frac{\Delta k_i}{k_i} + \left(1 - \omega_{Ki}\right) \frac{\Delta l_i}{l_i} \right) \tag{13}$$

By definition, reallocation effect is the part of the aggregate TFP growth not explained by the TFP growth arising within individual industries:

$$RE = \frac{\Delta T_m}{T_m} - \sum_{i=1}^{15} \varepsilon_i \frac{\Delta T_i}{T_i} = \sum_{i=1}^{15} \varepsilon_i \omega_{Ki} \frac{\Delta k_i}{k_i} + \sum_{i=1}^{15} \varepsilon_i \omega_{Li} \frac{\Delta l_i}{l_i} \tag{14}$$

The right-hand side of the equation (14) includes two components of reallocation effect, the first term being “capital reallocation effect” and the second term being “labor reallocation effect.” The sum of the capital and labor reallocation effects gives the total reallocation effect (RE).

One may prefer to work with marginal product of capital and labor rather than average product. Syrquin (1986) alternatively presents the reallocation effects as follows:

$$RE = \frac{1}{Q_m} - \sum_i \frac{\Delta L_i}{L_i} \cdot \left(fL_i - fL_m \right) + \frac{1}{Q_m} - \sum_i \frac{\Delta K_i}{K_i} \cdot \left(fK_i - fK_m \right) \tag{15}$$

where fL and fK represent marginal product of labor and capital. An increase in the share of industries with higher marginal product (of capital or labor) in total capital and labor leads to positive reallocation effects. Notice that reallocation effects sum to zero if the marginal products across industries are equal. This is the case of equilibrium. Therefore, the existence of reallocation effects due to shifts of capital and labor refers to disequilibrium (e.g. distortions) in factor markets.

2. Findings

The results of the above analysis are presented in Table 6 at the aggregate level and in Table 7 at the industry level. The results show that manufacturing TFP growth in Japan and Korea resulted almost entirely from intra-industry effect and reallocation effects are minimal. However, reallocation effects account for almost one-fourth of TFP growth in the case of Singapore.

In Japan and Korea, reallocation effects are relatively small. In Japan, reallocation effects are positive but negligibly small for the first two periods and negative at the level of 0.1 for the 1990s. Factor markets in Japan was not distorted much in the post-1973 period and the reallocation of labor and capital across industries did not result in large changes in average product of both capital and labor. This reflects the working of factor markets in Japan in such a way to maintain equilibrium and the virtual nonexistence of distortions in factor markets. Notice the large capital reallocation effect in the recession period of the 1990s. This is stimulated by the restructuring of Japanese industries in an era of deindustrialization and relocation of industries to overseas production sites where factor prices are lower.

In Korea, reallocation effects amount to a small positive figure for the 1970s and negative for the following two periods. and positive capital reallocation effects during the HCI drive (1970s) in Korea. Positive capital reallocation effect for this period indicates that such efforts acted as a bonus for TFP growth in Korea, i.e. capital's reallocation to the nurtured heavy and chemical industries where it could earn higher returns resulted in positive reallocation effect. However, labor reallocation effect for all periods is negative, meaning that labor was reallocated to those areas where its marginal product was lower. This is most likely due to increasing technological deepening[6] of Korean industries especially in the second and third periods when hi-tech industries were promoted and labor-intensive industries were replaced with capital-intensive ones. Note that negative labor reallocation effects are larger in these two periods.

At the industry level, basic machinery, electrical and electronic machinery and transport equipment industries stand out in both Japan and Korea with their relatively high intra-industry TFP gains. Basic metals (iron and steel) and chemical industries are also important contributors to intra-industry TFP in Korea. No single industry appears as an important industry in Japan but there are large differences among reallocation effects of industries during the bubble period (1985-1990). In Korea, basic metals, electrical machinery and transport equipment industries account for a large portion of reallocation effects whereas the contributions to reallocation effects by two primary industries (textiles and food) worked in the opposite direction.

In Singapore, on the other hand, for the whole period (1974-2000), reallocation effects account for almost a quarter of TFP growth. Capital reallocation effects are by far the most important of the reallocation effects. The government in Singapore actively controls the allocation of domestically available capital; manufacturing sector is dominated by foreign enterprises; and the government has been continually introducing foreign capital in high value-added areas such as electronics and chemicals. Largely positive capital reallocation effects imply that the allocation of foreign capital for higher value-added activities favored TFP growth. Labor shifts were negative during the wage-correction period (1979-85), but were during the period 1986-96. The former points to the fact that labor could not adapt to the restructuring efforts of the government to increase capital intensity. The latter, on the other hand, points to the positive response of labor toward governmental action to enhance labor productivity and skills in the 1980s. In this period, the measures the government took to improve labor skills and productivity helped improve marginal product of labor especially in the technology-intensive industries. Electrical and electronic machinery and chemical industries account for a significant portion of intra-industry TFP and reallocation effects and the contributions of two declining industries, transport equipment and petroleum, to TFP are largely negative (see Table 7).

To compare these results with similar other studies, Timmer and Szirmai (2000) found that factor reallocations constituted a very insignificant portion of labor productivity and TFP growth for

Table 7 The impact of the reallocations of capital and labor to aggregate TFP growth

JAPAN												
	Total impact				Intra-industry TFP				Total reallocation effects			
	1973-1984	*1985-1990*	*1991-2000*	*1973-2000*	*1973-1984*	*1985-1990*	*1991-2000*	*1973-2000*	*1973-1984*	*1985-1990*	*1991-2000*	*1973-2000*
Food	0.6	-95.6	-4.2	2.5	-0.4	3.8	2.7	2.7	1.1	-99.4	-6.8	-0.2
Tex.	5.4	-43.1	13.7	8.3	12.9	4.9	9.8	8.1	-7.5	-4.8	3.9	0.2
Wood	4.7	-6.9	3.6	5.1	8.2	3.3	3.2	5.1	-3.5	-10.1	0.4	0.1
Pap.	3.2	146.9	3.0	5.0	3.3	7.8	3.0	5.0	-0.1	139.1	0.0	0.0
Chem.	3.0	78.6	1.7	7.1	3.6	13.4	3.3	7.2	-0.7	65.2	-1.6	0.0
Pet.	-13.5	-20.6	-4.7	-3.7	-11.1	-0.5	-4.8	-3.7	-2.4	-20.2	0.1	0.0
Plas.	3.1	35.7	2.3	1.7	0.8	2.6	3.1	1.7	2.4	33.2	-0.8	-0.1
Min.	2.8	-19.2	3.6	4.4	4.6	3.8	3.3	4.4	-1.7	-22.9	0.3	0.1
Bas.met.	-12.7	-41.0	29.1	3.4	-6.8	4.4	27.3	3.2	-5.9	-45.4	1.8	0.2
Met.pr.	4.3	75.5	-2.0	5.3	6.1	7.0	-2.0	5.3	-1.8	68.5	0.0	0.0
Mach.	21.6	78.2	-5.8	10.4	20.4	8.7	-5.3	10.5	1.1	69.5	-0.5	-0.1
Elec.	49.3	-107.5	48.4	30.1	24.4	20.6	56.4	31.0	24.9	-128.0	-8.0	-0.9
Tran.	19.2	25.9	7.6	14.7	19.5	11.6	8.6	14.7	-0.3	14.3	-1.0	-0.1
Prec.	5.8	-5.9	2.7	3.0	5.6	0.6	2.5	3.0	0.2	-6.5	0.1	0.0
Others	3.2	-0.8	1.1	2.6	3.9	1.7	1.0	2.6	-0.7	-2.6	0.1	0.0
Total	100.0	100.0	100.0	100.0	94.8	93.6	112.1	100.7	5.2	6.5	-12.1	-0.7
KOREA												
	Total impact				Intra-industry TFP				Total reallocation effects			
	1971-1979	*1980-1988*	*1989-1996*	*1971-1996*	*1971-1979*	*1980-1988*	*1989-1996*	*1971-1996*	*1971-1979*	*1980-1988*	*1989-1996*	*1971-1996*
Food	13.9	-12.5	-0.1	-7.1	17.5	-5.4	2.1	7.1	-3.6	-7.1	-2.3	-14.2
Tex.	37.6	-9.4	-36.6	-23.3	29.8	21.5	-13.6	14.1	7.8	-30.8	-23	-37.4
Wood	1.6	1.7	0.1	-2.1	2.9	2.3	0.2	-0.2	-1.3	-0.6	-0.1	-1.8
Pap.	5.4	10.0	5.7	5.5	6.9	11.1	5.0	8.3	-1.5	-1.1	0.7	-2.9
Chem.	10.0	3.8	18.5	14.0	10.9	3.7	13.7	12.0	-0.9	0.1	4.9	2.0
Pet.	-18.3	0.0	9.6	-0.5	-17.7	0.2	9.3	0.4	-0.6	-0.2	0.3	-0.8
Plas.	-1.8	-1.4	-0.9	-1.9	-1.8	-2.5	-0.2	-2.7	0.0	1.1	-0.7	0.8
Min.	5.4	3.9	3.9	3.1	5.9	4.9	3.9	4.5	-0.5	-0.9	0.0	-1.4
Bas.met.	7.4	8.9	7.5	14.6	4.6	5.2	8.6	5.9	2.8	3.6	-1.1	8.7
Met.pr.	5.7	9.2	0.4	7.3	5.8	9.4	-1.4	6.7	-0.1	-0.2	1.8	0.6
Mach.	6.3	7.6	22.9	16.6	6.0	5.2	17	10.8	0.3	2.3	5.9	5.7
Elec.	13.4	47.0	37.1	43.2	9.8	30.2	38.3	22.0	3.6	16.8	-1.2	21.2
Tran.	7.6	21.1	35.4	26.3	6.8	17.4	27.2	16.5	0.8	3.7	8.2	9.8
Prec.	1.5	3.2	-0.9	1.8	1.5	3.3	-0.8	2.0	-0.1	-0.1	-0.1	-0.3
Others	4.3	6.9	-2.7	2.5	5.1	6.9	-2.5	4.8	-0.8	0.1	-0.1	-2.3
Total	100.0	100.0	100.0	100.0	94.1	113.4	106.7	112.3	5.9	-13.4	-6.7	-12.3

SINGAPORE												
	Total impact				Intra-industry TFP				Total reallocation effects			
	1974-1978	*1979-1985*	*1986-1996*	*1974-1996*	*1974-1978*	*1979-1985*	*1986-1996*	*1974-1996*	*1974-1978*	*1979-1985*	*1986-1996*	*1974-1996*
Food	7.1	1.5	-5.0	-5.6	8.7	1.7	-3.0	-4.6	-1.7	-0.2	-2.0	-1.0
Tex.	-9.2	-10.7	-5.2	-2.2	-8.7	-8.5	-3.0	0.0	-0.5	-2.2	-2.3	-2.2
Wood	-2.6	-6.4	-4.7	-6.2	0.0	-5.1	-3.0	-4.6	-2.6	-1.2	-1.8	-1.7
Pap.	-8.7	2.5	-1.0	9.2	-8.7	1.7	0.0	9.1	0.0	0.8	-1.0	0.2
Chem.	0.0	28.3	35.9	25.7	0.0	23.8	20.9	18.1	0.0	4.5	14.9	7.5
Pet.	12.7	9.1	-7.3	-16.6	17.5	10.2	-3.0	-13.6	-4.8	-1.1	-4.3	-3.0
Plas.	1.0	0.0	-0.8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-0.8	0.0
Min.	7.4	4.0	-4.5	-0.3	8.7	3.4	-3.0	0.0	-1.3	0.6	-1.5	-0.3
Bas.met.	-1.3	-0.2	-0.5	-5.1	0.0	0.0	0.0	-4.6	-1.3	-0.2	-0.5	-0.5
Met.pr.	-6.1	20.9	3.0	7.3	-8.7	17	3.0	4.6	2.6	3.9	0.0	2.7
Mach.	44.9	11.0	8.0	10.1	26.2	8.5	6.0	4.6	18.6	2.5	2.0	5.5
Elec.	9.2	68.9	91.2	107	-8.7	54.4	62.8	86.1	18	14.5	28.4	20.8
Tran.	45.9	-17.1	-9.5	-27.1	52.5	-13.6	-6.0	-22.7	-6.6	-3.5	-3.5	-4.4
Prec.	-0.5	-6.4	0.0	-0.8	0.0	-5.1	0.0	0.0	-0.5	-1.2	0.0	-0.8
Others	0.3	-5.3	0.5	4.7	0.0	-5.1	0.0	4.6	0.3	-0.2	0.5	0.2
Total	100.0	100.0	100.0	100.0	78.7	83.2	71.9	77.0	21.3	16.8	28.1	23.0

Note: Summations of contributions to intra-industry TFP and reallocation effects are identical to the figures in Table 6.
Source: Author's calculations

Indonesia, Korea, India, and Taiwan, for the period 1963-1993. In addition, Kawai (1999) found higher contribution by reallocation effects for Japanese TFP growth rate tin manufacturing, around 16 percent for the post-1970 period. The findings in this study reveal that the impact of structural changes in the three countries on aggregate manufacturing level (i.e. Harberger's yeast effects) in general is less significant than their impact at the industry level (i.e. mushroom effects). Then, it seems safe to assert that industrial policies gave way to a mushroom-type industrial growth process.

Syrquin (1995) notes that the initial acceleration of the contribution of reallocation effects to TFP and output growth subsequently slows down as an economy industrializes. At the industrialized level, as represented by Japan in this study, the contribution of reallocation effects is thus expected to be minimal. This is partly explained by the "exhaustion of the shifts" (see Syrquin 1995).

To sum up, during periods of heavy involvement by governments in capital reallocation in Singapore and in Korea (1970s), reallocation of resources acted as an additional source for TFP growth. Labor was largely displaced during the course of technological sophistication due to the replacement of labor-intensive industries with capital-intensive ones. However, Singaporean government actively sought for ways to improve the skills of the labor force and succeeded in enhancing the contribution of labor to TFP growth in the post-1985 period. Japanese government stood neutral and did not distort factor markets. This brought about a lack of significant contribution of resource shifts to TFP growth. However, the deep recession in the 1990s stimulated changes in the factor markets and the resulting shifts of factors ran counter to aggregate TFP growth.

VI. Conclusion

The results show that aggregate manufacturing productivity growth originated almost entirely from intra-industry productivity gains. The reallocation of factor inputs within the manufacturing sector, in general, is found to be unimportant as a source of aggregate productivity growth. In Singapore, the shifts of capital and labor were more important as additional sources of productivity growth.

Due to the limitations in estimating productivity (both labor and total factor productivity), a certain level of bias in estimations above may be expected to exist. Therefore, there may be under- or overestimations of the actual level of reallocation effects. There is a need to mention a few shortcomings of the methodology[7] used in this study. First, input homogeneity as assumed here may lead to overestimation of the real impact of resource reallocation. Differing factor returns (productivity) may be a result of differing qualities of these factors. When factors are reallocated from sectors with low returns to those sectors with higher returns, an improvement in the misallocation of factors is expected and this may improve the quality of these factors. Therefore, the reallocation effect contains improvement in disequilibrium as explained above and an improvement in input quality. If factor inputs are shifting to industries that have higher level of productivity due to better factor input quality, the effects of resource allocation will also include the increased quality of factor inputs and hence reallocation effects will be overestimated. Estimations of capital stock and labor input taking into account their qualitative aspects may reduce this bias.

Second, in the shift-share analysis, it is assumed that all labor and capital have the same marginal productivity. Hence, average productivity in an industry will not be affected by shifting factors. However, marginal productivity of factors within an industry may be lower than the average productivity. If, for instance, labor with low marginal productivity is absorbed into other industries, average productivity will rise in the industry that is sending out labor. This increase will be a part of the intra-industry productivity effect but it was caused by a shift of labor to other branches. Therefore, the impact of structural change may be underestimated. If one can measure marginal productivity of capital and labor correctly, this bias will disappear.

Finally, a major problem with the above analyses, as pointed out by Timmer and Szirmai (2000), is the inability to incorporate inter-industry spillovers and backward and forward linkages which may result in productivity improvements. Rapid growth in an industry with strong forward and backward linkages may impact positively on output and productivity growth in other industries. A further investigation incorporating these into the framework may prove to be helpful in this respect.

Endnotes

1. Harberger (1998) describes the mushroom and yeast effects as follows: "... yeast causes bread to expand very evenly, like a balloon being filled with air, while mushrooms have the habit of popping up, almost overnight, in a fashion that is not easy to predict."
2. From 1979 to 1985, Singapore government, which effectively controlled wage levels since the early 1970s, introduced a high-wage policy in order to discourage labor-intensive production and to encourage higher value-added generation. It is called corrective because the government deliberately maintained wages at low levels until 1979 in order to attract labor-intensive foreign investment, on which the development of the manufacturing sector depended. By increasing wages, the government aimed at easing the distortion on the value of labor. The goal of this effort was to discourage labor-intensive manufacturing as increasing wages was expected to reduce the dependency on labor.
3. Manufacturing employment declined in Japan for the whole period and during the third periods in Korea and Singapore. The decline in Korea and Singapore is associated with restructuring via technological deepening.
4. In 1972, the government established the National Wages Council and effectively controlled wage increases. In addition, various productivity improvement and skills upgrading schemes were established and put in effect from the late 1970s on. The most important of these are the Skills Development Fund, a fund where both employees and employers contribute, established to improve the skills of low-skill labor, and Singapore Productivity Movement of the 1980s.
5. The restriction that real value-added of each industry add up to the aggregate real value-added is difficult to verify since normalization of value-added is done by using specific producers' price indices. Generally, real value-added figures of industries do not add up to real value-added of the manufacturing sector when they are calculated independently. To avoid such an inconsistency, real manufacturing value-added was calculated as the sum of real industry value-added figures.
6. Korean government established a number of public institutions from the mid-1970s in order to establish a national innovation system where technologies were learned, created, and disseminated to private firms. Various facilities for research and development for private firms were also put in place. As a result, private firms acquired sophisticated technologies and upgraded their technology.
7. See Syrquin (1986) and Timmer and Szirmai (2000) for more details on the shortcomings of the methodology employed in this study.

References

Amsden, Alice H. 1989. *Asia's Next Giant: South Korea and Late Industrialization*. New York: Oxford University Press.

Ark, Bart van and M. Timmer. 2003. Asia's Productivity Performance and Potential: The Contribution of Sectors and Structural Change. Paper presented at the conference "Leading East Asia in the 21st Century", Tokyo, 30 May 2003.

Chenery, Hollis B., Sherman Robinson, and Moshe Syrquin. 1986. Industrialization and Growth: A Comparative Study. New York: Oxford University Press.

Choi, Jeong Pyo. 1990. Factor Demand and Production Technology in Korean and Taiwanese Manufacturing. In Jene K. Kwon, ed., *Korean Economic Development*, Greenwood Press, 167-181.

Fagerberg, Jan. 2000. Technological Progress, Structural Change and Productivity Growth: A Comparative Study. *Structural Change and Economic Dynamics* 11: 393-411.

Harberger, Arnold C. 1998. A Vision of the Growth Process. *American Economic Review* 88 (1): 1-32.

Jalava, Jukka, S. Heikkinen, and R. Hjerppe. 2002. Technology and Structural Change: Productivity in the Finnish Manufacturing Industries, 1925-2000. Paper presented at "XIII Economic History Congress," Buenos Aires, 28 June 2002.

Jorgenson, Dale W. 1995. *Productivity: Volume 1 - Postwar U.S. Economic Growth*. MIT Press.

Jorgenson, Dale W. and M. Sullivan. 1981. Inflation and Corporate Capital Recovery. In Charles Hulten, ed., *Depreciation, Inflation, and the Taxation of Income from Capital*, Urban Institute.

Kaldor, Nicholas. 1963. *Essays on Economics Stability and Growth.* London: Gerald Duckworth & Co..

Kaldor, Nicholas. 1966. *Causes of the Slow Rate of Economic Growth of the United Kingdom, An Inaugural Lecture*. Cambridge: Cambridge University Press.

Kawai, Hiroki. 1999. Productivity Growth and Structural Change in Japanese Economy: Resource Reallocation and Firm Dynamics. Paper presented at "Pacific Economic Outlook - Structure Meeting," Osaka, September 13-14, 1999.

Massell, B. F. 1961. A Disaggregated View of Technical Change. *Journal of Political Economy* 69: 547-557

OECD. 1996. *Industry Productivity: International Comparison and Measurement Issues.*

Pyo, Hak-Kil. 1998. *Estimates of Fixed Reproducible Tangible Assets in the Republic of Korea, 1953-1996*. Korea Development Institute.

Syrquin, Moshe. 1995. Patterns of Structural Change. In H. Chenery and T.N. Srinivasan, eds., *Handbook of Development Economics*, *Volume 1*. Elsevier, 203-273.

Syrquin, Moshe. 1986. Productivity Growth and Factor Reallocation. In Hollis Chenery, S.Robinson, and M. Syrquin, eds., *Industrialization and Growth: A Comparative Study*. World Bank, 229-262.

Szirmai, Adam. 1993. Comparative Productivity in Manufacturing: A Case Study for Indonesia. In A. Szirmai, B. van Ark, and D. Pilat, eds., *Explaining Economic Growth: Essays in Honor of Angus Maddison*. North Holland, 217-240.

Targetti, Ferdinando. 1992. *Nicholas Kaldor - The Economics and Politics of Capitalism as a Dynamic System*. Oxford: Clarendon Press.

Timmer, Marcel P. and A. Szirmai. 2000. Productivity Growth in Asian Manufacturing: The Structural Bonus Hypothesis Examined. *Structural Change and Economic Dynamics* 11: 371-392.

Wagner, Karin and Bart van Ark, eds. 1996. International Productivity Differences: Measurement and Explanations. Contributions to Economic Analysis No: 233. Elsevier.