RIETI Discussion Paper Series 04-E-002

Physical and Human Capital Deepening and New Trade Patterns in Japan

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RIETI Discussion Paper Series 04-E-002

Physical and Human Capital Deepening and New Trade Patterns in Japan*

Paper prepared for the Fourteenth Annual East Asian Seminar on Economics

International Trade

September 5-7, 2003, Taipei

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Revised Version: November, 2003

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Abstract

This paper investigates the deepening of the international division of labor and its effect on factor intensities in Japan, mainly focusing on the manufacturing sector. In the first half of the paper, we analyze the factor contents of trade and find that Japan's factor content net-exports of capital and non-production labor grew rapidly while net-exports of production workers fell by a large amount during the period from 1980–2000. Interestingly, the decline in the factor content of net-exports of production workers was almost entirely caused by Japan's trade with China and Hong Kong.

According to our decomposition analysis, however, most of the macro-economic change in the capital-labor ratio and the change in the skilled-labor ratio is attributable to a "within-industry" shift rather than a "between-industry" shift. Although we clearly see a drastic increase in VIIT and outsourcing to foreign countries, particularly to Asian countries, our empirical analysis provides only weak evidence that the deepening international division of labor contributes to changes in factor intensities in each industry.

Our results suggest that specialization in the export of skilled-labor-intensive products may have contributed to the increase in the relative demand for skilled (professional, technical, managerial, and administrative) labor within industry. However, our results suggest that changes in trade patterns (specialization in capital-intensive production) cannot explain the rapid growth of capital-labor ratios in Japan.

1. Introduction

Until the beginning of the 1990s, Japan accomplished comparatively high economic growth through an exceptionally rapid accumulation of physical and human capital. Table 1.1 compares growth accounting results for the US economy (by Jorgenson, Ho, and Stiroh, 2002) with those for the Japanese economy (Fukao, Inui, Kawai, and Miyagawa, 2003). We can see that, compared with the US, Japan's economic growth until 1990 was relatively more dependent on labor quality growth and increases in physical capital per capita. However, as is well-known, high economic growth based on rapid capital accumulation is not sustainable in the long-run because of the diminishing rate of return to physical and human capital.

INSERT Table 1.1

Evidence suggests that Japan is caught in this trap of diminishing rates of return. Figure 1.1 shows that as the physical capital-output ratio increased over the past three decades in Japan, the rate of return to physical capital declined continuously. Comparing South Korea and Japan with other OECD economies, Pyo and Nam (1999), showed that the two countries both enjoyed a more rapid rise in their capital output ratios but also suffered a faster decline in the rate of return to capital. Turning from physical to human capital, Katz and Revenga (1989) found that while educational earnings differentials expanded drastically in the US in the 1980s, the college wage premium in Japan increased only slightly. As Genda (1997) showed, the underlying reason is that the employment of skilled workers such as older college graduate males expanded rapidly in Japan, resulting in an excess supply of skilled workers relative to the limited availability of management positions that contributed to the stagnation of earnings for older college graduates. Probably partly as a result of these declines in the rate of return, the accumulation of physical and human capital has slowed down over the past decade (Table 1.1).[1]

INSERT Figure 1.1

We should note that according to standard international trade theory, rapid growth based on capital accumulation will be sustainable if the economy gradually specializes in physical and human capital intensive products. Under such a specialization process, the factor price equalization mechanism will work to offset the diminish rate of return to physical and human capital. For Japan, the 1990s were an age of "globalization": the country has expanded its international division of labor with other East Asian countries through international trade and direct investment. The purpose of this paper is to examine this deepening of the international division of labor and evaluate how much of the diminishing rate of return mechanism was cancelled out by the international division of labor.

Several recent studies, such as Feenstra and Hanson (1996b, 1999, 2001), Kimura (2001), and Fukao, Ishido, and Ito (2003), have shown that the fragmentation of the production process and vertical intra-industry trade between developed and developing economies may have enhanced the vertical division of labor within each industry. This type of international division of labor would cause a deepening of the physical and human capital within each industry in developed economies. However, since the resulting capital deepening will occur within each industry, we cannot correctly analyze this type of division of labor by using inter-industry trade data. Consequently, we study the international division of labor by looking at both inter-industry trade and intra-industry trade.

The remainder of the paper is organized as follows. In section 2, we examine physical and human capital deepening in Japan. In section 3, we take a broad look at Japan's inter-industry trade and factor contents in order to measure to what extent Japan's capital deepening is offset by

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[1] Godo (2001) found that the speed of catch-up of Japan's average schooling years to the US level slowed down during the 1980s because of the decline in the Japan/US ratio in average schooling years for tertiary education.

international trade. In section 4, after providing an overview of the changes in Japan's intra-industry trade and vertical division of labor, we conduct econometric analyses to investigate the determinants of the changes in factor intensities using industry-level data. Section 5, finally, presents our conclusions.

2. Physical and Human Capital Deepening in the Japanese Economy

In this section, we look at the trends of physical and human capital deepening in Japan and examine the macro-economic change in the capital-labor ratio and the change in the skilled-labor ratio (the percentage of skilled labor in total labor) by decomposing these changes into the contribution of the increase in the capital-labor ratio or the share of non-production workers within each industry (the "within effect") and the contribution of the reallocation between industries (the "between effect").

First, we consider the increase in the capital-labor ratio and the share of non-production (or skilled) workers in the manufacturing sector as well as the Japanese economy as a whole. As Figure 2.1 shows, the capital-labor ratio measured as real capital stock (in 1990 price) divided by the number of workers has increased considerably over the last three decades: the capital-labor ratio for both the economy as a whole and manufacturing industry grew five-fold from three million yen per person in 1970 to 15 million yen per person in 1998.

INSERT Figure 2.1

In order to examine the human-capital deepening in Japan, we compiled data on the number of non-production or skilled workers using the data of the *Population Census*. "Skilled workers" are persons whose profession is classified either as "professional and technical" or as "managerial and administrative." We define "non-production workers" here as persons whose profession falls into one of the following categories: professional and technical occupations, managers and administrators, clerical and secretarial occupations, sales occupations, services occupations, protective occupations, occupations in agriculture, forestry and fishing, occupations in transportation and telecommunications, and other occupations. The definition of "non-production workers" is much broader than the definition of "skilled workers" and includes not-highly educated workers. The share of non-production (or skilled) workers in the total number of workers has been increasing, as shown in Figure 2.2, though the growth rate is much more moderate than that of the capital-labor ratio. In the period from 1980–2000, the share of non-production workers in manufacturing increased from 27.7% in 1980 to 30.7% in 2000.[2] The share of skilled workers also grew during 1980-2000: in the manufacturing sector, it rose from 9.0% to 10.5%, while in the economy as a whole it expanded from 9.8% to 13.9%.[3]

INSERT Figure 2.2

The increase in the capital-labor ratio and in the share of non-production (or skilled) workers can be decomposed into the contribution of the increase within each industry ("within effect") and the contribution of the reallocation between industries ("between effect") using the following decomposition formula:

$$\Delta P = \sum_{i=1}^{n} \bar{S}_i \Delta P_i + \sum_{i=1}^{n} \bar{P}_i \Delta S_i$$

i: industry (i=1, 2, ..., n)

$$P = \sum_{i=1}^{n} K_i / \sum_{i=1}^{n} L_i \text{ , or } \sum_{i=1}^{n} L_{s,i} / \sum_{i=1}^{n} L_i$$

$P_i = K_i/L_i$: Capital-labor ratio in industry i, or

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[2] This latter value, though, is substantially below the peak of 32.3% reached in 1997. The decline in the share of non-production workers since 1998 is most likely the result of firms' restructuring efforts – the dismissal of managers, sales personnel, etc. – following the further deterioration of the Japanese economy.

[3] For details on the compilation of the skilled/non-production workers data, see Appendix.

$=L_{si}/L_i$: Share of non-production (or skilled) workers in total number of workers in industry i

$S_i= L_i/L$: Share of workers in industry i in total number of workers in the economy as a whole or in the manufacturing sector

Variables with an upper bar denote the average value of the period. Δ denotes the change in the variable overtime. The first term of the right hand side represents the increase in the factor intensity within each industry ("within effect") while the second term represents the reallocation between industries ("between effect").

Ideally, we should use the most disaggregated cross-industry data available for our decomposition analysis. However, because of the data limitation, we had to use the relatively aggregated data of the JIP database for our decomposition analysis.[4] We should note that our estimates of the within effect might suffer from upward biases as a consequence of this aggregation problem.

The results of our decomposition analysis are reported in Tables 2.1 and 2.2. Table 2.1, which summarizes the decomposition of capital-labor ratio growth, shows that there was a negative between effect for most periods of 1970-1998, indicating the decline of the capital-intensive sectors of the economy. Moreover, the magnitude of the between effect is very small throughout the entire 1970-1998 period and most part of the growth of capital-labor ratio is attributable to the within effect. On the other hand, Table 2.2, which summarizes the decomposition of the growth of the share of skilled or non-production workers, shows that here the between effect was positive in all cases, showing that the share of human capital intensive industries has continuously increased both in the manufacturing sector and in the economy as a whole. The within effect was also positive with the

[4] In the following decomposition, we used data of 35 manufacturing industries and 43 non-manufacturing industries.

exception of two cases in the period of 1990-2000, and it was always greater than the between effect except for these two cases. The major implication of our results is that the within effect is very large. Some part of the within effect may have been caused by the international division of labor within each industry. We analyze this issue in section 4.

INSERT Tables 2.1 and 2.2

Our decomposition analysis thus suggests that physical and human capital deepening in the Japanese economy is mostly attributable to the within-industry shift, not to the between-industry shift, though we could see a negative between effect during the period 1990-2000 for the share of non-production workers in the manufacturing sector and the share of skilled workers in the whole economy. In the last two decades, and particularly in the 1990s, the age of "globalization," both the within-industry capital deepening and the between-industry allocation may have been caused by expanding international trade. The between-industry shift may be partly explained by the change in patterns of inter-industry trade which affects the size of each industry in Japan, while the within-industry shift may be explained by the change in patterns of intra-industry trade which affects the mixes of factor inputs in each industry. In the following sections, we will examine the change in Japan's trade patterns and analyze the determinants of the changes in factor intensities in Japan.

3. Japan's Inter-industry Trade and Factor Contents

In this section, we take a general look at the pattern of Japan's inter-industry trade in the last two decades. Next, we estimate how factor contents in Japan's international trade changed during this period.

3.1 Overview of Japan's International Trade

Although Japan's overall import-GDP ratio has gradually declined over the last two decades, imports of manufactured products have actually grown faster than the economy as a whole (Table 3.1). As Figure 3.1.B shows, the increase in imports mainly concentrated on electrical machinery and labor intensive goods, such as apparel and wooden products, which in this figure are classified as "other manufacturing products." Since the share of the manufacturing sector in GDP declined during this period, the ratio of imports of manufactured products to gross value added in the manufacturing sector increased rapidly: by 11.5 percentage-points from 15.2% in 1985 to 26.7% in 2000 (Table 3.1). The United States experienced a similar trend during the 1980s, when this ratio jumped by 12.4 percentage-points from 18.3% in 1978 to 30.7% in 1990 (Sachs and Shatz 1994). We would expect an impact of a similar scale on Japan's manufacturing sector as a result of the recent surge in imports..[5]

INSERT Table 3.1 and Figure 3.1

On the other hand, the commodity composition of Japan's exports at the two-digit level has remained relatively stable over the last fifteen years (Figure 3.1.A). Nevertheless, looking at trade patterns at a more detailed commodity classification level, it becomes clear that Japan's specialization has changed: the country is increasingly specializing in the export of capital goods and key parts and components in the automobile and electrical machinery sector, while it has become a net importer of many household electrical goods.[6]

Japan's new imports of electrical machinery and labor intensive products are mainly provided by East Asian economies. Figure 3.2 shows that nine East Asian economies (China, Hong Kong,

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[5] Comparing export shares and import penetration in the US, Canada, UK and Japan during the period from 1974-93, Campa and Goldberg (1997) found import penetration to be extremely stable and significantly lower in Japan than in the other countries. However, if we were to conduct a similar analysis using more recent data, it seems probable that this conclusion no longer holds.

[6] The share of machine parts in Japan's total exports to East Asia increased from 31.7 % in 1990 to 40.2 % in 1998, while the share of capital goods, which include some machine parts, increased from 53.2 % to 56.8 % during the same period (MITI 1999).

Taiwan, Korea, Singapore, Indonesia, Thailand, the Philippines, and Malaysia) provided 64.2% of Japan's electrical machinery imports and 49.2% of Japan's imports of "other manufacturing products" in 2000. The East Asian economies' share in Japan's total imports of machinery and intermediate products such as metal products and chemical products has also increased rapidly.

INSERT Figure 3.2

As a result of these trends, East Asia during the 1990s became the most important destination for and origin of Japan's international trade. As Figure 3.3 shows, trade with the nine East Asian economies accounted for 48.5% of Japan's total manufactured imports and 41.0% of total manufactured exports in 2000.

INSERT Figure 3.3

This rise in Japan's imports of labor intensive products and exports of capital and technology intensive products (such as machinery and advanced intermediate products) can be easily recognized as a deepening of the international division of labor with the relatively unskilled-labor abundant East Asian economies. But how can we interpret the rapid increase in the two-way trade in electrical machinery? Table 3.2, presenting Japan's bilateral trade in electrical machinery with China and Hong Kong in 1999 at the 3-digit level, provides a clue.

INSERT Table 3.2

This table shows two important facts. First, at the detailed commodity level, there seems to be a division of labor within the electrical machinery industry. With China and Hong Kong, Japan is a net importer of relatively labor-intensive products (such as television and radio-broadcast receivers and electrical household goods) and a net exporter of technology-intensive other products. This means that in order to correctly understand the division of labor and factor contents in trade between Japan and East Asia, we need to analyze trade patterns at the detailed commodity level; otherwise, the analysis will suffer from aggregation bias problems (Feenstra and Hanson 2000).

The second important fact this table shows is the existence of huge intra-industry trade between Japan and China plus Hong Kong. For example, in the case of television receivers, the total trade value is 37 times greater than the trade balance. It seems that we need to analyze intra-industry trade in order to correctly evaluate the impact of trade on Japanese economy.

3.2 Factor Contents in Japan's Trade of Manufacturing Products

In this subsection, we analyze the changes in factor contents in Japan's trade. In order to avoid aggregation bias, we should calculate factor contents at the most disaggregated level possible.[7] The most disaggregated data on direct factor requirements are those available in the *Report on Industrial Statistics* of the Ministry of International Trade and Industry, which is based on the *Census of Manufactures*. The data is classified by the 4-digit Standard Industrial Classification for Japan, which listed 540 manufacturing industries in 1990.

There is no direct converter between this industry classification and the 9-digit HS classification used by the Ministry of Finance for the compilation of Japan's international trade statistics. In order to link the two sets of data – factor requirements and international trade – we used the basic industry classification of the *Japan Input-Output Tables 1990* by the Management and Coordination Agency, which lists 341 manufacturing industries, as our benchmark classification. Using supplementary converter tables of the I-O statistics, we converted both the factor requirement data and the international trade data into the basic I-O classification. As a result, we obtain factor requirement and international trade data for 246 manufacturing industries.[8] In order to estimate

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[7] Using Management and Coordination Agency, Japanese Government "1980-85-90 Linked Input-Output Tables," Sakurai (2001) estimated factor contents in Japan's trade for the years 1980, 85, and 90.

[8] The factor requirement data of the *Census of Manufactures* is on an establishment basis and each establishment is classified by its most important product. Since many establishments produce various commodities simultaneously, this classification method is problematic. The I-O converter from the

indirect factor requirements, we used the corresponding I-O table.

Ideally, we would use up-to-date factor requirement data and I-O tables in order to take account of technology change in Japan. Unfortunately, the factor requirement data is available only until 1990, because the *Census of Manufactures* after that year does not cover headquarter activities. Because of this constraint, we used constant factor requirement and I-O data of 1990 for our analysis of the entire 1980-2000 period.[9]

Factor content in Japan's trade in year t (t = 1980, 1990, 2000) is calculated by

$$\boldsymbol{X_t} = \boldsymbol{D}\,(\boldsymbol{I} - \boldsymbol{A})^{-1}\,\boldsymbol{T_t}$$

where ($K \times 1$) vector $\boldsymbol{X_t} = [x_{k,t}]$ denotes the total contents of factor k in Japan's trade of year t. ($K \times J$) matrix $\boldsymbol{D} = [d_{k,j}]$ denotes the quantity of primary factor k directly used per unit of output in industry j in year 1990. ($J \times J$) matrix $\boldsymbol{A}$ is the input-output matrix of year 1990.[10] ($J \times 1$) vector $\boldsymbol{T}_t$ is the net-export vector of year t in 1990 prices. In order to derive trade data in 1990 prices, we used the deflators of the Management and Coordination Agency's *Japan Linked Input-Output Table* (various years) and the *Wholesale Price Index* of the Bank of Japan at the 3-digit level.[11]

We analyzed factor content in terms of the following four primary factors: physical capital (in

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Census of Manufactures to the basic I-O classification takes account of this problem and converts establishment-based data into activity-based data. We used the I-O converter in order to construct the factor requirement data for each I-O classification-based industry. Therefore, our factor requirement data were also transformed into the activity-based data.

[9] Because of this methodology, there is a risk of overestimating factor contents in recent trade in the case of industries where total factor productivity has grown rapidly.

[10] The input-output matrix here covers only manufacturing industries. Therefore, our analysis does not include indirect factor requirements through changes in production in non-manufacturing industries.

[11] The conversion of trade statistics at the HS 9-digit level into trade data at classified at the basic industry level of the I-O tables in 1990 price was conducted by H. Nosaka, T. Inui, K. Ito and K. Fukao as part of the Japan Industrial Productivity (JIP) database project. The result is included in the JIP database. For more detail on this database see Fukao, Inui, Kawai, and Miyagawa (2003).

1990 prices, book value), production labor (number of workers), non-production labor (number of workers), and land (in 1990 prices, book value). In order to analyze how the increase in Japan's trade with the East Asian economies affected Japan's factor markets, we subdivided Japan's total net exports in each industry into gross exports and gross imports by six regions, namely, (1) China and Hong Kong, (2) the NIEs-3 (Taiwan, South Korea, and Singapore), (3) the ASEAN-4 (Indonesia, Thailand, Malaysia, and The Philippines), (4) the US, (5) the EU, and (6) all other economies.

The results of the factor content analysis for the years 1980, 1990, and 2000 are reported in Table 3.3. Reflecting Japan's huge trade surplus, Japan is a net exporter of all the four primary factors. For example, according to our calculations, in the year 2000, Japan recorded factor-content net exports of 363,000 production workers, which represents 4.7 % of the total of production workers (7,717,000) in manufacturing in 1990. Compared with the trade pattern observed in 1990, the 2000 figure for factor content net-exports of production labor represents a decline of 42%. This decline was almost entirely caused by Japan's trade with China and Hong Kong (Table 3.4). In the year 2000, about one-third of factor content gross-imports of production workers came from China and Hong Kong (Table 3.3).

INSERT Table 3.3 and Table 3.4

In the case of non-production workers, there were factor content net-exports of 378,000 production workers in the year 2000, which represents 10.9% of the total of non-production workers (3,456,000) in manufacturing in 1990. Compared with trade patterns in 1980, net-exports of non-production workers have increased by 89,000, which is equivalent to 2.6% of the total of non-production workers in 1990. The major increase in this factor content occurred in Japan's trade with the US (Table 3.4).

In the case of land, factor content net-exports in 2000 amounted to 1.36 trillion yen (in 1990 prices), which is equivalent to 10.5 % of the total land value (12.9 trillion yen) used in manufacturing in 1990. Net exports of land have gradually declined over the last twenty years (Table 3.4).

Capital stock factor content net-exports in 2000, meanwhile, stood at 9.12 trillion yen (in 1990 prices), which represents 16.5% of the total capital stock (55.4 trillion yen) in manufacturing in 1990. Compared with 1980, this represent an increase in net-exports of capital stock by 1.1 trillion yen or 2.0% of the total capital stock in 1990 (Table 3.4).

Relative to the total amount of each of the four primary input factors used in manufacturing, Japan exported a large amount of capital and non-production labor but only a small amount of production labor in 2000. Since non-production workers on average are more educated than production workers and Japan is a country abundant in physical and human capital, the above results are consistent with the Heckscher-Ohlin theory.

As Table 3.3 shows, in the period from 1980-2000, Japan's factor content net-exports of production workers fell by 3.3%, while net-exports of non-production workers rose by 2.6%. This change in trade patterns has the effect of increasing the implied supply-ratio of production/non-production workers available to the manufacturing sector for other use by about 5.9%. More than one-half of this change (3.2%) was caused by Japan's trade with China and Hong Kong.

During 1980-2000, Japan's factor content net-exports of capital stock grew by 2.0%, while net-exports of workers overall (production and non-production) decreased by 1.5%. This change in the trade pattern has the effect of reducing the implied supply of capital stock per worker available to the manufacturing sector for other use by 3.5%. Thus, compared with the impact on the implied supply ratio of production/non-production workers, the effect of recent changes in trade patterns on the implied supply of capital stock per worker has been small.

By a similar calculation using the results of the factor content analysis at the 4-digit level carried out by Feenstra and Hanson (2000), we can evaluate the impact of US trade on its factor markets. This shows that in the period of 1982-94, changes in US trade patterns had the effect of increasing the implied supply ratio of production/non-production workers available to the manufacturing sector for other use by 1.0%, while the implied supply of capital stock per worker available to the manufacturing sector for other use fell by 2.3%.[12] Thus, compared with the US, Japan experienced a much more drastic change in factor content net-exports over the last two decades in terms of its implied supply ratio of production/non-production workers available to the manufacturing sector for other use.

The trends shown here mean that, Japan's factor content net-exports have changed in a direction that offsets the effect of the accumulation of physical and human capital per capita. Japan has come to export more physical and human capital intensive products over the past two decades. However, compared with the rapid deepening of physical and human capital in the macro-economy described in Section 2, the offsetting effect of international trade seems to be small. Table 3.5 compares physical and human capital deepening in the Japanese manufacturing sector as a whole with that purely attributable to changes in factor contents of trade. Although the average annual growth rate of capital-labor ratio for the manufacturing sector total is 7.60% for the 1980-1998 period, the growth rate becomes very small at 0.18 % when we only take account of change in factor contents of trade. As for the growth rate of the share of non-production workers, the offsetting effect of international trade is also small for the 1980-1990 period and throughout the 1980-2000 period. However, in the 1990s, the contribution of international trade to the growth of the share of non-production workers in the Japanese manufacturing sector is much larger, which implies a

[12] In the period of 1982-94, the United States saw an increase in its factor content net-imports of production (non-production) workers in manufacturing of 8.2% (7.2%). It also experienced a rise in factor content net-imports of capital stock in manufacturing of 5.5% and a decline in net-exports of (production plus non-production) workers of 7.8% of total workers in manufacturing.

significant effect of international trade on Japan's human capital deepening.

INSERT Table 3.5

4. Japan's Intra-Industry Trade and Determinants of Factor Intensity within Industry

So far, we have found that the macro-level capital-labor ratio has been increasing over the last two decades, and that most of the increase is attributable to the within-industry shift and not the between-industry shift. Moreover, most of the macro-level increase in the skilled or non-production labor share in the total number of workers has also been induced by the within-industry shift. As has been argued in previous studies, the international division of labor through the fragmentation of production processes and the import of unskilled labor-intensive intermediate inputs may have contributed to an increase in the relative demand for skilled labor in each industry. That is, if firms fragment their production into discrete activities and move non-skill-intensive activities abroad, then trade will shift employment toward skilled workers within those industries. This type of international division of labor has been referred to as "outsourcing" in the recent literature. Feenstra and Hanson (1996a, 1996b, 1999) and Hijzen, Görg and Hine (2003), for example, provide econometric evidence of a positive relationship between outsourcing and the demand for skilled labor. Although the international fragmentation of production has been increasing rapidly in Japan in recent years, too, contributing to changes in trade patterns, studies analyzing the impact of fragmentation on labor and capital are very limited.[13]

Moreover, vertical intra-industry trade (VIIT), i.e. intra-industry trade where goods are differentiated by quality, may have a large impact on factor demands within each manufacturing industry in Japan. As Falvey (1981) pointed out in his seminal theoretical paper, commodities of the

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[13] An exception is Sakurai (2000), who conducts a similar analysis for Japan. See section 4.2 for the details.

same statistical group but of different quality may be produced using different mixes of factor inputs. Therefore, developed economies like Japan may export physical and human capital-intensive products of high-quality and import unskilled labor-intensive products of low quality from developing economies. As a result, an increase in VIIT may also raise the physical and human capital intensity in Japan.

In the following subsections, we briefly outline the changes in outsourcing and VIIT patterns by industry in Japan for the period from 1988–2000.[14] We also discuss the relationship between changes in factor demand and trade patterns by industry. Using industry-level as well as firm-level data, we conduct econometric analyses to investigate the determinants of the observed growth in the skilled-labor share in total workers and in the capital-labor ratio. We should note that following analyses are limited to the manufacturing sector due to data constraints.

4.1 Industry-Level Overview of Fragmentation and Factor Intensity

Japan's trade patterns have undergone various changes over time: in particular, the share of trade with Asian countries in overall trade has increased markedly. In this subsection, utilizing Japan's customs data and the JIP database, we investigate VIIT and outsourcing from foreign countries by industry, and analyze the impacts of these trends on shift in factor demand in Japan.

Figure 4.1 shows the share of VIIT, a broad outsourcing measure, and a narrow outsourcing measure by industry for the year 2000, while Figure 4.2 presents the average annual growth rates of these values from 1988–2000 by industry.[15] Following major preceding studies such as Greenaway, Hine, and Milner (1995) and Fontagné, Freudenberg, and Péridy (1997), our VIIT measure is

[14] As for the capital-labor ratio, due to data constraints, our analysis focuses only on the period from 1988-98.

[15] For the definition of VIIT and broad and narrow outsourcing measures, see Appendix. For more detailed analyses on VIIT in Japan and East Asia, see Fukao, Ishido, and Ito (2003).

calculated based on the assumption that the gap between the unit value of imports and the unit value of exports for each commodity reveals the qualitative differences of the products exported and imported between the two countries. Our measures of broad and narrow outsourcing are constructed following Feenstra and Hanson (1999). The broad outsourcing measure expresses imported intermediate inputs relative to total expenditure on non-energy intermediate inputs in each industry. The narrow outsourcing measure is expressed by the imported intermediate inputs purchased from the same JIP industry as the good being produced divided by the total expenditure on non-energy intermediate inputs in each industry. Figure 4.1 shows that the level of the VIIT share in the year 2000 was relatively high (more than 30 percent) in publishing and printing, other chemicals, metal products, electrical machinery, other electrical machinery, and precision machinery and equipment. On the other hand, the broad outsourcing measure was high (more than 15 percent) in food products (livestock products and processed marine products), apparel and accessories, lumber and wood products, leather and leather products, basic chemicals, chemical fibers, non-ferrous metals, other electrical machinery, and precision machinery and equipment. The narrow outsourcing measure was high (more than 5 percent) in food products (livestock products and processed marine products), lumber and wood products, pulp, paper, and paper products, leather and leather products, basic chemicals, petroleum products, steel manufacturing, non-ferrous metals, other electrical machinery, other transportation equipment, and precision machinery and equipment. Figure 4.2 shows that the VIIT share and outsourcing measures increased in most manufacturing sectors during the period from 1988–2000. In particular, we find that the outsourcing measures increased relatively more in food products, textile products, and machineries, while the VIIT share increased relatively more in food products, textile products, petroleum and coal products, non-ferrous metals and motor vehicles.

INSERT Figure 4.1 and Figure 4.2

Next, let us look at the correlations between changes in factor intensities, the VIIT share, and the outsourcing measures. Table 4.1 summarizes the correlation coefficients between the annual growth rates of the shares of skilled workers, non-production workers, the VIIT share, and the broad and narrow outsourcing measures for the period from 1988–2000. Although we can see a positive correlation between skilled workers' share and the VIIT share, the correlation coefficient is not statistically significant. Moreover, the correlation coefficients between the capital-labor ratio and the VIIT share and between non-production workers' share and the VIIT share are negative, though not significant. As for changes in the outsourcing measures and factor intensities, a significantly positive correlation can be seen only in the case of skilled workers' share. Therefore, the simple correlation coefficient analysis does not provide strong support for the conjecture that outsourcing or VIIT may have contributed to physical and human capital deepening in each industry.

INSERT Table 4.1

4.2 Econometric Analysis

In this section, we conduct a statistical analysis of the determinants of factor intensities using the industry-level data from 1988–2000. Several previous studies have analyzed the impact of fragmentation on skill upgrading (human capital deepening). Using detailed industry-level data for the US, Feenstra and Hanson (1996a, 1996b, 1999) estimate the effect of international outsourcing on wage inequality. Hijzen, Görg and Hine (2003) conduct a similar analysis using UK data for 53 manufacturing industries for the period from 1982–1997. As for Japan, Sakurai (2000) analyzes this issue using data for 39 manufacturing industries for the period from 1987–1990. While the studies on the US and the UK found a strong positive relationship between outsourcing and wage inequality, Sakurai's (2000) study on Japan did not produce such clear-cut evidence. Sakurai explains that his ambiguous result might be due to the short estimation period. The present paper aims at applying and extending the Feenstra and Hanson approach by using JIP industry-level data (35 manufacturing industries) for the period from 1988–2000. In addition, we take account of the role of skill-biased technological change (SBTC) in the increase in skilled (non-production) worker intensity, utilizing the JIP IT (Information Technology) database.[16] As Hijzen, Görg and Hine (2003) mention, the inclusion of the 1990s in the analysis is thought to be crucial as international fragmentation and information technology progressed rapidly in the past decade. However, one drawback of our analysis is that we cannot calculate wage bills for skilled (non-production) and unskilled (production) workers due to data constraints. Therefore, we assume that the relative wage rates of skilled (non-production) and unskilled (production) workers have not changed over time, and we use the ratio of the number of skilled (non-production) workers to the total number of workers as a proxy for the share of skilled (non-production) workers' wage bill in the total wage bill.

A translog cost function approach, based on the work of Berman, Bound and Griliches (1994) and Feenstra and Hanson (1996b), is usually employed in the literature to estimate skill upgrading and we follow this approach here. Similarly, following previous studies, we consider capital as a fixed input in the short-run, while skilled and unskilled (non-production and production) workers are variable factors of production. Therefore, the short-run translog cost function can be presented as:

$$\ln C_i = \alpha_0 + \sum_{j=1}^{J} \alpha_j \ln w_{ij} + \sum_{k=1}^{K} \beta_k \ln x_{ik} + \frac{1}{2}\sum_{j=1}^{J}\sum_{s=1}^{J} \gamma_{js} \ln w_{ij} \ln w_{is} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \delta_{kl} \ln x_{ik} \ln x_{il} + \sum_{j=1}^{J}\sum_{k=1}^{K} \varphi_{jk} \ln w_{ij} \ln x_{ik} \tag{4.1}$$

where C_i is the variable cost for industry i, w_{ij} denotes the wages of workers in skill group j, and x_{ik} denotes the fixed inputs or outputs k. Differentiating the translog cost function with respect to wages

[16] According to the argument put forward by Feenstra and Hanson (1999), both skill-biased technological change and outsourcing can be considered to be associated with within-industry changes in skill intensity as a result of their effect on the relative productivity of different skill groups. That is, as fragmentation or outsourcing take the form of moving unskilled labor-intensive processes from a developed country to a developing country, they have a similar effect as technological change.

yields the factor payments to skill group *j* over the total wage bill.

$$S_{ij} = \alpha_j + \sum_{s=1}^{J} \gamma_{js} \ln w_{ij} + \sum_{k=1}^{K} \varphi_{jk} \ln x_{ik} \tag{4.2}$$

Assuming that quality-adjusted wages will be identical across industries, the wage terms can be dropped from the right-hand-side of the equation (4.2). We consider technological change, VIIT, and outsourcing as structural variables and assume there are three kinds of capital, i.e., IT hardware, IT software, and non-IT capital. A full set of year dummies is included in order to capture economy-wide skill upgrading as well as year-to-year changes in the wage levels faced by all industries. Therefore, we estimate the following equation:

$$\begin{aligned} S_{ijt} = {} & \varphi_{j0} + \varphi_{j1} \ln(IThard / VA)_{it} + \varphi_{j2} \ln(ITsoft / VA)_{it} + \varphi_{j3} \ln(NonIT / VA)_{it} \\ & + \varphi_{j4} \ln VA_{it} + \varphi_{j5} (RD \exp / VA)_{it} + \varphi_{j6} VIIT_{it} + \varphi_{j7} Outsourcing_{it} + \varphi_{j8} D_t \\ & + v_i + \varepsilon_{it} \end{aligned} \tag{4.3}$$

where *IThard*, *ITsoft*, and *NonIT* denote IT hardware stock, IT software stock, and non-IT capital stock, respectively; *VA* is value added in industry *i*, *RDexp/VA* is a proxy for technological change calculated as expenditure on research and development over value added, *VIIT* represents the VIIT value over industry *i*'s shipment, *Outsourcing* reflects either broad or narrow outsourcing, and *D* is a full set of year dummies. Subscript *t* represents time. In order to examine different effects of VIIT with Asian countries and VIIT with other countries, we prepare three variables representing VIIT: first, Japan's VIIT with all countries in the world divided by the industry's shipment; second, Japan's VIIT with nine Asian countries divided by the industry's shipment; and third, Japan's VIIT with all the countries except for the nine Asian countries divided by the industry's shipment.[17]

In addition, using the industry-level data, we examine whether the international division of

[17] For more details on the definition of the variables and data sources, see Appendix.

labor contributed to physical capital deepening in Japan. We use the capital-labor ratio (physical capital stock divided by number of workers, *KL*) as the dependent variable and regress it on the logarithm of the wage rate relative to the rental price of capital (*ln(wage/rental price)*) and variables representing the degree of the international division of labor.

The results of the GLS estimation are presented in Table 4.2. This shows that the estimated coefficients on *ln(IThard/VA)*, *ln (VA)*, and *RDexp/VA* are significantly positive in all cases where skilled workers' share (*SKILLED*) or non-production workers' share (*NONPROD*) in the total number of workers is used as the dependent variable (columns (1) to (4)). The results imply that: 1) IT hardware intensity has a positive impact on skill upgrading, and skill-biased technological change may have increased the share of skilled (non-production) workers; 2) the scale-effect is positive and greater value-added is associated with a higher skilled (non-production) workers' share; and 3) R&D intensity which is a proxy for technological change, has a positive impact on skill upgrading. On the other hand, a significantly negative coefficient is obtained for *ln(NonIT/VA)* in all the cases but one for columns (1) to (4), which suggests that increases in non-IT capital intensity favor unskilled (production workers) in Japan. As for IT software intensity, the estimated coefficients are positive in columns (1) and (2) but negative in columns (3) and (4), though they are not statistically significant in any of the cases.

As for the VIIT share, the estimated coefficients are significantly positive in columns (1) and (2) but statistically insignificant in columns (3) and (4), suggesting that VIIT raises the skill-intensity calculated as the share of workers whose occupation is classified as professional and technical or managerial and administrative. Moreover, looking at the magnitude of the coefficients in column (2), *VIITasia9/shipment* has a much larger coefficient than *VIITnon-asia9/Shipment*. This may reflect the fact that vertical FDI in the Asian countries tends to consist of the transfer of low-skill production work to these countries while high-skilled employees remain at home. We can confirm that Japanese manufacturing industries realized skill upgrading as a result of the international division of labor with the nine Asian countries. When the skill-intensity is calculated as the share of non-production workers, however, VIIT does not have a significant impact on skill upgrading though the estimated coefficient on VIIT is positive in columns (3) and (4). This result might be a reflection of the fact that Japanese firms reduced the share of non-production and non-professional workers (such as sales persons) in the course of the restructuring efforts during the 1990s.

Although narrow outsourcing has a positive coefficient and the difference between broad and narrow outsourcing has a negative coefficient in columns (1) to (4), none of coefficients are significant. We could not find strong evidence that outsourcing to foreign countries contributed to skill upgrading in Japan, which is not consistent with the results of previous studies on the United States and the United Kingdom.

As for the capital-labor ratio (column (5)), none of the explanatory variables except for the VIIT variable have statistically significant coefficients. Although *VIITworld/shipment* has a significantly positive coefficient, the small value of the Wald-statistics indicates the weak explanatory power of the equation. Again, we could not obtain strong evidence that VIIT and outsourcing contributed to physical capital deepening in Japan, suggesting that capital deepening was caused by other factors.

INSERT Table 4.2

5. Conclusion

Our goal in this paper has been to investigate the changing trade patterns and their effect on factor intensities in Japan, mainly focusing on the manufacturing sector. Given the observation that the capital-labor ratio and the share of skilled workers in the total number of workers have been growing for the last couple of decades, we first conducted decomposition analyses and found that most of the macro-economic change in the capital-labor ratio and the change in the skilled-labor ratio were attributable to a within-industry shift rather than a between-industry shift. The between-industry shift can be partly explained by the change in patterns of inter-industry trade which affects the size of each industry. However, the large within-industry effect led us to suspect that the division of labor and intra-industry trade between Japan and Asian countries may have contributed to the within-industry increase in capital intensity and skilled-labor intensity. Therefore, we first analyzed factor contents of trade from the aspect of inter-industry trade, and then analyzed whether the deepening of the international division of labor and vertical intra-industry trade contributed to the within-industry change in factor intensities in Japan.

We found that Japan's factor content net-exports of capital and non-production labor grew rapidly while net-exports of production workers fell by a large amount. Interestingly, the decline in the factor content of net-exports of production workers was almost entirely caused by Japan's trade with China and Hong Kong. Although international trade to a considerable extent contributed to the growth in the share of non-production workers in the Japanese manufacturing sector as a whole, most of the macro-level accumulation of physical capital was not offset by the growth in factor content net-exports of physical capital.

Although we clearly saw a drastic increase in VIIT and outsourcing to foreign countries, particularly to Asian countries, our empirical analysis provided only weak evidence that the deepening international division of labor contributed to the change in factor intensities in Japan. We did not find a significant and robust positive relationship between fragmentation and capital-labor ratios. As for skill intensity, we found that VIIT had a strong positive effect on the increase in the share of skilled workers when these were defined as those holding professional and technical or managerial and administrative occupations. However, we did not find such a relationship when the skill-intensity was calculated as the share of non-production workers. We should note that the skilled (professional, technical, managerial, and administrative) labor share in the total number of workers is only around 10% and is much lower than the share of non-production workers which is around 30%. According to our results, specialization in the export of skilled-labor-intensive products may have contributed to the increase in the relative demand for skilled (professional, technical, managerial, and administrative) labor within industry. However at the same time, our results could also imply that changes in trade patterns (specialization in capital-intensive production) did not offset the excess supply of capital in Japan. Probably one plausible explanation for this small offsetting effect might be that VIIT or fragmentation patterns are not determined by the abundance of capital endowments, but by other factors such as endowments with skilled labor, the agglomeration of industries, highly-developed supporting industries, etc. Davis and Weinstein (2003), who empirically tested the determinants of the firm-level trade patterns, conclude that after controlling for national factor accumulation, firm level export decisions seem to have little correlation with the capital intensity of their production process. We do not know yet whether this story applies to the case of industry-level trade patterns and which factors matter for trade patterns. This is, however, an issue that deserves closer scrutiny in future investigations.

Appendix. Definition of Variables Used in the Econometric Analysis and Data Sources

1. Labor data

Data on skilled and unskilled labor were constructed mainly using the *Population Census of Japan,* published by Statistics Bureau, Ministry of Public Management, Home Affairs, Posts, and Telecommunications. The *Population Census* is the most fundamental and reliable survey and is conducted every five years, covering all permanent and temporary residents in Japan. The survey report provides data on employment by detailed occupational classification (3-digit-level) and by industry. We used the 1980, 1985, 1990, and 1995 employment data as benchmarks and interpolated the data for years between the benchmarks. As for the years after 1995, we utilized the *Employment Status Survey* data, published by Statistics Bureau, Ministry of Public Management, Home Affairs, Posts, and Telecommunications, because the results of the 2000 *Population Census* have not been released yet. The *Employment Status Survey* is based on a series of surveys that cover approximately one percent of the working population. We first calculated the skilled labor share for 1992, 1997, and 2002 based on the *Employment Status Survey*. Then, for the 1996 and 1997 data on skilled labor, we extended the 1995 employment data by occupation and industry using the growth rate of the skilled labor share from 1992 to 1997. For the 1998, 1999 and 2000 data, we extended the 1997 data using the growth rate of the skilled labor share from 1997 to 2002. The *Population Census* and the *Employment Status Survey* allow us to construct a measure of skill that is more accurate than the one based on production and non-production labor generally used in preceding studies. In the *Population Census* and the *Employment Status Survey*, workers are basically classified according to 10 Major Groups as shown in Appendix Table 1. We distinguished two skill groups (skilled or unskilled) as well as production/non-production classifications. Skilled workers are those classified in Major Groups 1 (Professional and Technical Occupations) and 2 (Managers and Administrators). Otherwise, workers are classified as unskilled. Moreover, production workers are those classified in Major Group 9 (Plant and Machine Occupations, Craft and Related Occupations, and Occupations in Mining and Construction). Workers classified in all the other Major Groups are categorized as non-production workers.

INSERT Appendix Table 1

2. Measurement method and data source for vertical intra-industry trade

In order to identify vertical and horizontal IIT we adopt a methodology used by major preceding studies on vertical IIT such as Greenaway, Hine, and Milner (1995) and Fontagné, Freudenberg, and Péridy (1997). The methodology is based on the assumption that the gap between the unit value of imports and the unit value of exports for each commodity reveals the qualitative differences in the products exported and imported between the two economies.

We break down the bilateral trade flows of each detailed commodity category into the following three patterns: (a) inter-industry trade (one-way trade), (b) intra-industry trade (IIT) in horizontally differentiated products (products differentiated by attributes), and (c) IIT in vertically differentiated products (products differentiated by quality). Then the share of each trade type is defined as:

$$\frac{\sum_j (M^Z_{kk'j} + M^Z_{k'kj})}{\sum_j (M_{kk'j} + M_{k'kj})} \qquad \text{(A1)}$$

where the variables are defined as

$M_{kk'j}$: value of economy k's imports of product j from economy k';

$M_{k'kj}$: value of economy k''s imports of product j from economy k;

$UV_{kk'j}$: average unit value of economy k's imports of product j from economy k';

$UV_{k'kj}$: average unit value of economy k''s imports of product j from economy k.

The upper-suffix Z denotes one of the three intra-industry trade types, i.e., "One-Way Trade" (OWT) "Horizontal Intra-Industry Trade" (HIIT) and "Vertical Intra-Industry Trade" (VIIT) as in Appendix Table 2.

For our analysis, we chose to identify horizontal IIT by using the range of relative export/import unit values of 1/1.25 (i.e., 0.8) to 1.25.

Appendix Table 2. Categorization of trade types

Type	Degree of trade overlap	Disparity of unit value
"One-Way Trade" (OWT)	$\frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \leq 0.1$	Not applicable
"Horizontal Intra-Industry Trade" (HIIT)	$\frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} > 0.1$	$\frac{1}{1.25} \leq \frac{UV_{kk'j}}{UV_{k'kj}} \leq 1.25$
"Vertical Intra-Industry Trade" (VIIT)	$\frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} > 0.1$	$\frac{UV_{kk'j}}{UV_{k'kj}} < \frac{1}{1.25}$ or $1.25 < \frac{UV_{kk'j}}{UV_{k'kj}}$

We used Japan's customs data provided by the Ministry of Finance (MOF). Japan's customs data are recorded at the 9-digit HS88 level and the data classified by HS88 are available from the year 1988. The 9-digit HS88 code has been changed several times for some items, and the HS code was revised in 1996. Using the code correspondence tables published by the Japan Tariff Association for code changes, we made adjustments to make the statistics consistent with the original HS88 code. In Japan's customs statistics, export data are recorded on an f.o.b. basis while import data are on a c.i.f. basis. We should note that our estimate of the VIIT share is biased upward because of this difference.

3. Outsourcing measures

Following Feenstra and Hanson (1999) and other previous studies, we constructed outsourcing measures as follows:

For each industry *i*, we measure imported intermediate inputs as

$$\Sigma_j \text{[input purchases of good } j \text{ by industry } i\text{]*[(imports of good } j\text{)/(consumption of good } j\text{)]} \quad \text{(A2)}$$

where consumption of good *j* is measured as (shipments + imports - exports). The *broad* measure of foreign outsourcing is obtained by dividing imported intermediate inputs by total expenditure on non-energy intermediate inputs in each industry. The *narrow* measure of outsourcing is obtained by restricting attention to those inputs that are purchased from the same JIP industry as the good being produced. Using Japan's customs data, Hiromi Nosaka, Tomohiko Inui, Keiko Ito, and Kyoji Fukao compiled trade data at the basic industry classification of the I-O tables in 1990 prices as part of the Japan Industrial Productivity (JIP) database project at the Economic and Social Research Institute, Cabinet Office, Government of Japan. The correspondence between the Fukao-Ito industry classification and the 1980-85-90 Japan Linked Input-Output standard classification for manufacturing industries is presented in Appendix Table 3. The correspondence between the JIP classification and the Fukao-Ito classification for manufacturing industries is presented in Appendix Table 4. When calculating the outsourcing measures, we first calculated the input coefficients by Fukao-Ito industry and aggregated the imported intermediate inputs in each Fukao-Ito industry into the corresponding JIP industry. As for the narrow outsourcing measure, we restricted the Fukao-Ito industry subscripts *i* and *j* in equation (A2) to be within the same JIP industry. We should note that we only took account of intermediate inputs from manufacturing industries.

INSERT Appendix Tables 3 and 4

4. Other variables used in the industry-level econometric analyses

IT hardware (million yen, 1990 prices)

We mainly used IT hardware stock data in the JIP database. For details on the JIP database, see Fukao, Inui, Kawai, and Miyagawa (2003). Tangible IT assets (hardware) include office machines, computers, computer peripherals, communications equipment, optical instruments and medical instruments. As only data until 1998 are available in the JIP database, we extended the IT hardware stock until 2000 by using the annual growth rate of real IT hardware stock from 1998 to 2000 in JCER (Japan Center for Economic Research) IT data.[18]

IT software (million yen, 1990 prices)

We constructed industry-level software stock data using the JIP database, the JCER IT data, and software investment data underlying Motohashi (2002) and Jorgenson and Motohashi (2003).[19] The JCER data provide real software stock by 2-digit industry but include only order-made software. In the JIP database, real software stock data which cover in-house software and general application software as well as order-made software are available until 1999. Therefore, we first divided the JIP software stock value at the macro-level into each 2-digit industry using the distribution ratios in the JCER IT data. Then, we further divided it into the JIP industry classification, using the distribution ratios of IT hardware by JIP industry. Since the JIP software stock data are available only until 1999, for the year 2000, we calculated the macro-level real software stock, using Motohashi's software investment data and software deflators.

Non-IT physical capital stock (million yen, 1990 prices)

Physical capital stock data including IT hardware stock by industry are available in the JIP

[18] We wish to thank Professor Tsutomu Miyagawa at Gakushuin University and Ms. Yukiko Ito at the Japan Center for Economic Research for providing the JCER IT data.

[19] We are also grateful to Dr. Kazuyuki Motohashi at Hitotsubashi University for providing the data.

database until 1998. We extended the data up to 2000 by using the investment data in METI's *Report on Industry Statistics*, which is based on the *Census of Manufactures*. First, we aggregated the data on investment in fixed assets in the *Report on Industry Statistics* into the JIP industry-level and then deflated them using the gross domestic capital formation deflator (plant and equipment) in the *Annual Report on National Accounts* released by the Cabinet Office, Government of Japan. We assumed a depreciation rate of 10 percent and estimated the real physical capital stock for 1999 and 2000. Non-IT physical stock is defined as physical capital stock minus IT hardware stock.

Value added (million yen, 1990 prices)

We used value added data in the JIP database up to 1998. The data for 1999 and 2000 were constructed using the *SNA Input-Output Tables* released by the Cabinet Office, Government of Japan.

R&D expenditure (million yen, 1990 prices)

We used R&D expenditure data in the JIP database up to 1998. We extended the data up to 2000 using the *Report on the Survey of Research and Development*, Ministry of Public Management, Home Affairs, Posts and Telecommunications. The deflators were taken from the *Annual Report on the Promotion of Science and Technology*, Ministry of Education, Science, Sports and Culture.

VIIT (%)

The variable VIIT is defined as the share of vertical intra-industry trade in total trade values. For our definition of vertical intra-industry trade and data sources, see Appendix 2.

VIITworld/Shipment (%)

This variable is calculated as (VIIT*(exports+imports)/2/domestic shipment). *VIITworld* takes account of Japan's trade with all countries in the world. Data on domestic shipments were taken from the JIP database up to 1998 and from the *SNA Input-Output Tables* for 1999 and 2000.

VIITasia9/Shipment (%)

This variable is calculated in the same way as *VIITworld/Shipment*. *VIITasia9* takes account of Japan's trade with the following nine Asian countries: China, Korea, Taiwan, Hong Kong, Singapore, Indonesia, Malaysia, the Philippines, and Thailand.

VIITnon-asia/Shipment (%)

This variable is calculated in the same way as *VIITworld/Shipment*. *VIITnon-asia* takes account of Japan's trade with all countries other than the nine Asian countries.

KL (million yen per person, 1990 prices)

The capital-labor ratio was calculated using physical capital stock data and data on number of workers taken from the JIP database for 1988–1998.

Wage (1990=1.0)

The labor quality-adjusted wage index was taken from the JIP database for 1988–1998.

Rental price (1990=1.0)

The rental price index of capital was taken from the JIP database for 1988–1998.

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Table. 1.1 Sources of Economic Growth: US-Japan Comparison

<Panel A> The Result of Growth Accounting for the US Economy by Jorgenson et al (2002): 1973-2000 (Annual Rate, %)

	Real GDP growth	Man-hour growth	Labor productivity (GDP/man-hour) growth	TFP growth	Contribution of labor quality growth	Contribution of capital sevices/man-hour growth		
						Sub-total	Contribution of IT capital	Contribution of non-IT capital
	a	b	c=a-b	d=c-e-f	e	f=g+h	g	h
1973-1995	2.78%	1.44%	1.33%	0.26%	0.27%	0.80%	0.37%	0.43%
1995-2000	4.07%	1.99%	2.07%	0.62%	0.21%	1.24%	0.87%	0.37%

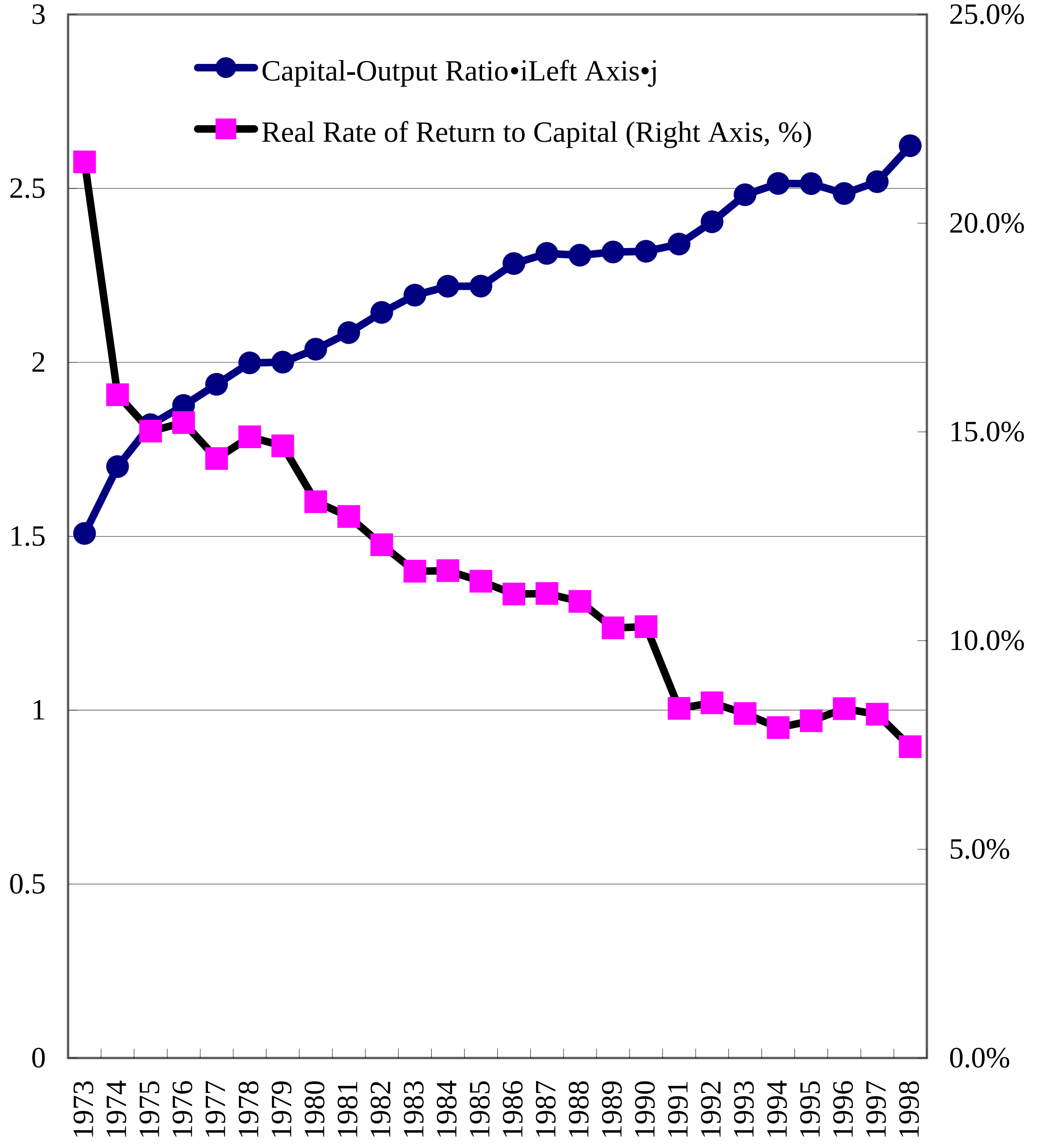
Jorgenson et al. (2002)

<Panel B> The Result of Growth Accounting for the Japanese Economy: 1973-1998 (annual rate, %)

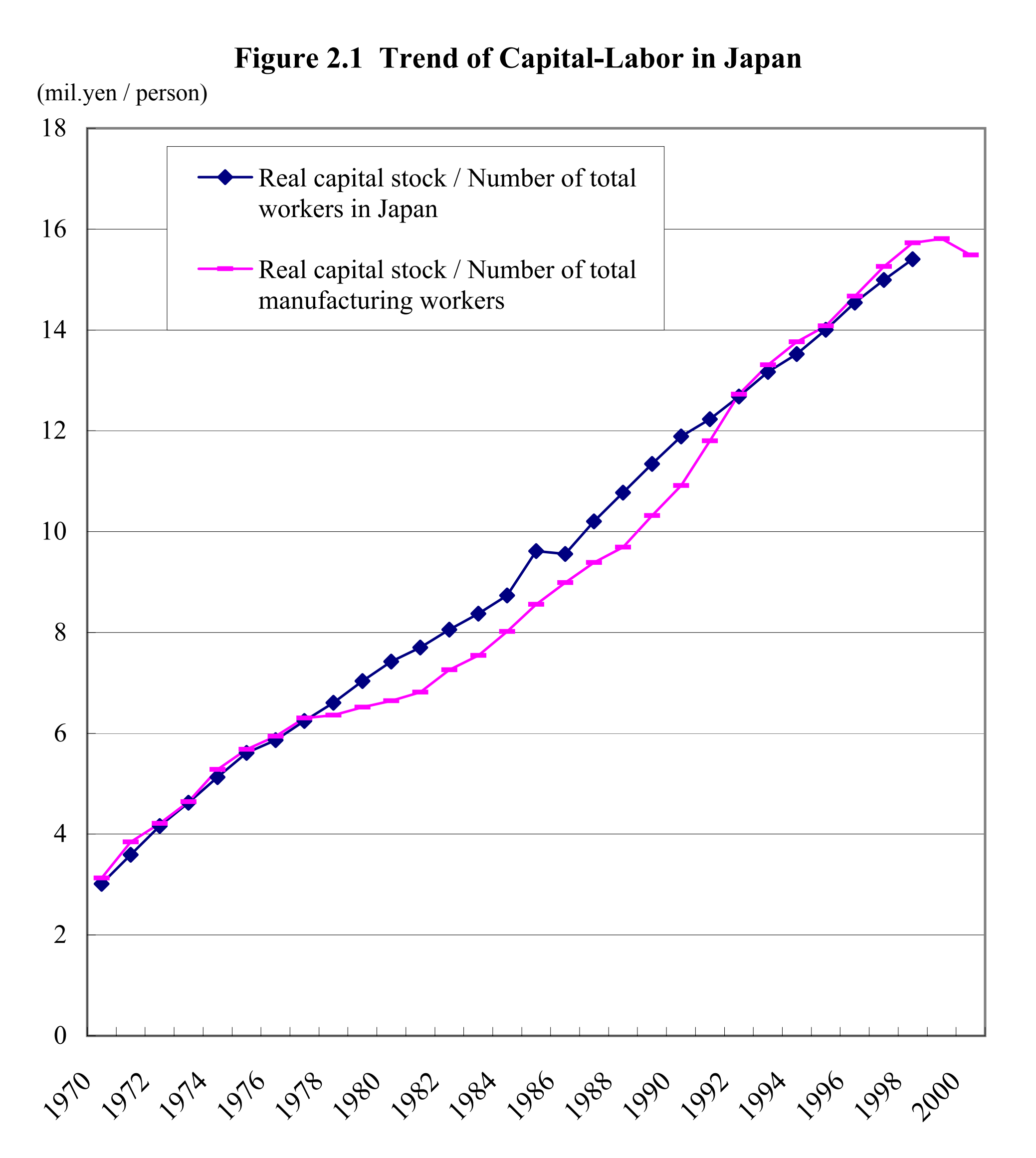
	Real GDP growth	Man-hour growth	Labor productivity (GDP/man-hour) growth	TFP growth	Contribution of labor quality growth	Contribution of capital services/man-hour growth		
						Sub-total	Contribution of IT capital	Contribution of non-IT capital
	a	b	c=a-b	d=c-e-f	e	f=g+h	g	h
1973-83	3.56%	1.53%	2.03%	-0.30%	0.65%	1.68%	0.16%	1.52%
1983-91	3.94%	1.79%	2.15%	0.40%	0.46%	1.29%	0.37%	0.92%
1991-98	1.25%	-0.08%	1.34%	0.03%	0.21%	1.10%	0.33%	0.76%
						1995-98	0.52%	0.63%

Source: Fukao et al. (2003), Table 2.2. Original figures are calculated from JIP database.

Figure 1.1 Japan's Capital-Output Ratio and Rate of Return to Capital: 1973-1998

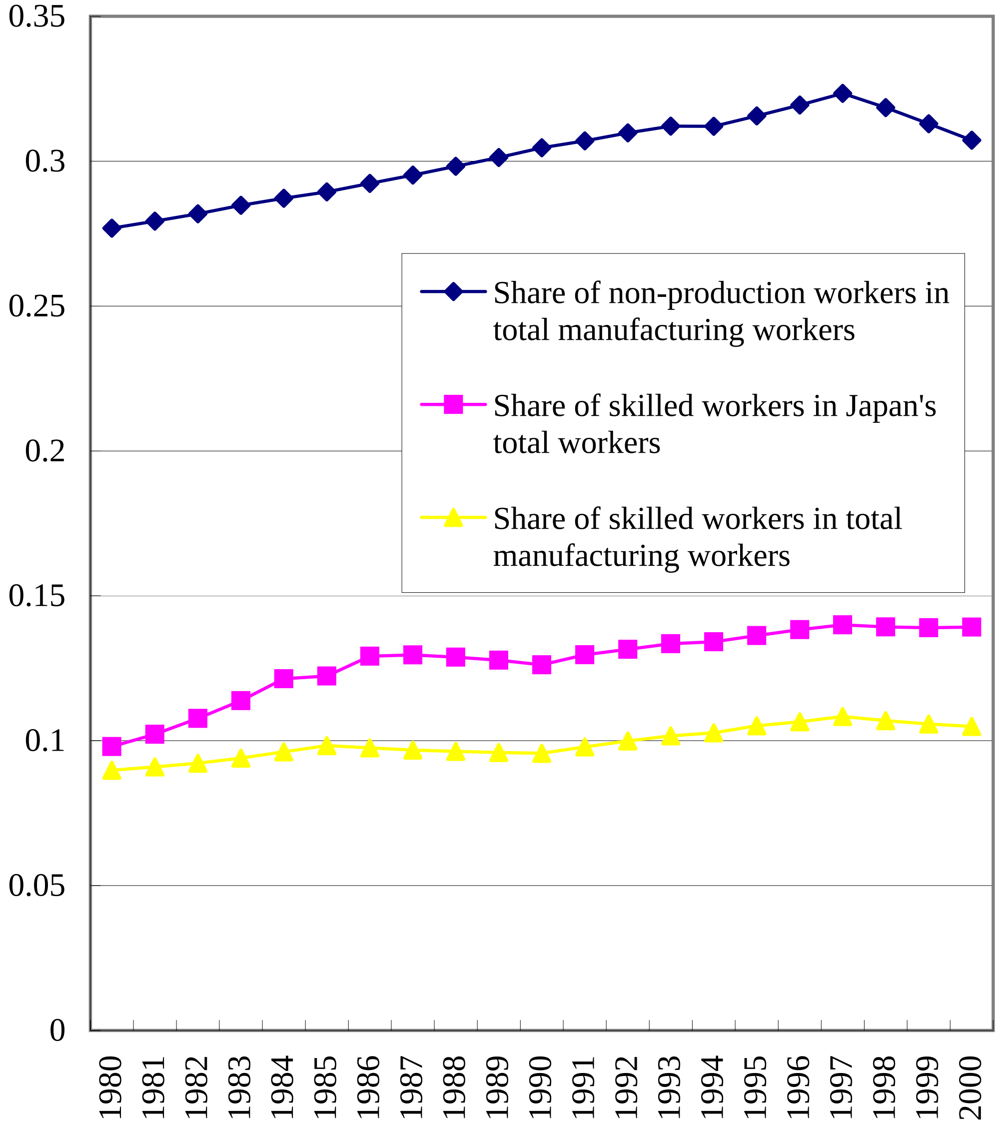


The numerator of the rate of return to capital is the current surplus of the national accounts deflated by the GDP deflator.
Source: JIP Database



Source: Authors' calculation based on JIP Database.

Figure 2.2 Share of Skilled and Non-production Workers in Total Workers



Source: Authors' calculation based on *Population Census* data.

Table 2.1 Decomposition of Capital-Labor Ratio Growth

<Panel A> Decomposition of capital-labor ratio growth: manufacturing sector

(annual rate, %)

	1970-80	1980-90	1990-2000	1980-2000
Growth rate of K-L ratio	11.24	6.43	4.18	6.65
Between effect	-0.45	-1.01	-0.05	-0.90
Within effect	11.69	7.44	4.24	7.55

<Panel B> Decomposition of capital-labor ratio growth: the whole economy

(annual rate, %)

	1970-80	1980-90	1990-98	1980-98
Growth rate of K-L ratio	14.65	6.01	3.70	5.97
Between effect	0.13	-0.81	-0.45	-0.92
Within effect	14.52	6.82	4.15	6.89

Note: The capital-labor ratio is defined as the real capital stock (in 1990 price) divided by the number of v

Source: Authors' calculation based on JIP database.

Table 2.2 Decomposition of the Growth of the Share of Skilled or Non-Production Workers

<Panel A> Decomposition of the growth of the share of non-production workers: manufacturing sector

(annual rate, %)

	1980-90	1990-2000	1980-2000
Growth rate of the share	1.00	0.08	0.55
Between effect	0.12	0.16	0.14
Within effect	0.88	-0.07	0.41

<Panel B> Decomposition of the growth of the share of skilled workers: manufacturing sector

(annual rate, %)

	1980-90	1990-2000	1980-2000
Growth rate of the share	0.65	0.97	0.84
Between effect	0.29	0.25	0.27
Within effect	0.36	0.71	0.57

<Panel C> Decomposition of the growth of the share of skilled workers: the whole economy

(annual rate, %)

	1980-90	1990-2000	1980-2000
Growth rate of the share	2.88	1.03	2.10
Between effect	1.02	1.06	1.02
Within effect	1.86	-0.02	1.08

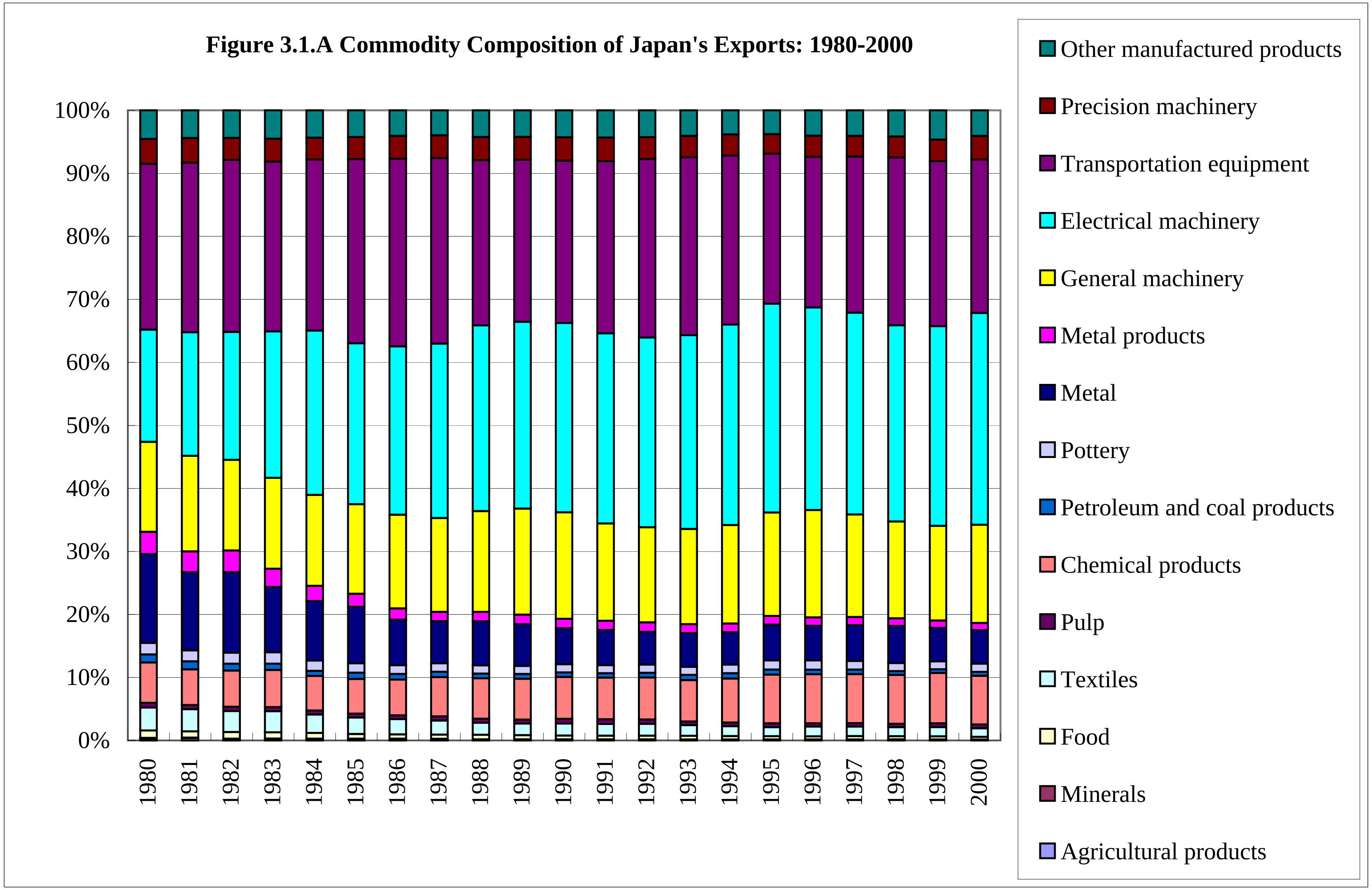
Source: Authors' calculation based on *Population Census* data and the JIP database.

Table 3.1 Japan's Share of Imports and Manufacturing Sector in GDP, Employment, and Gross Value Added

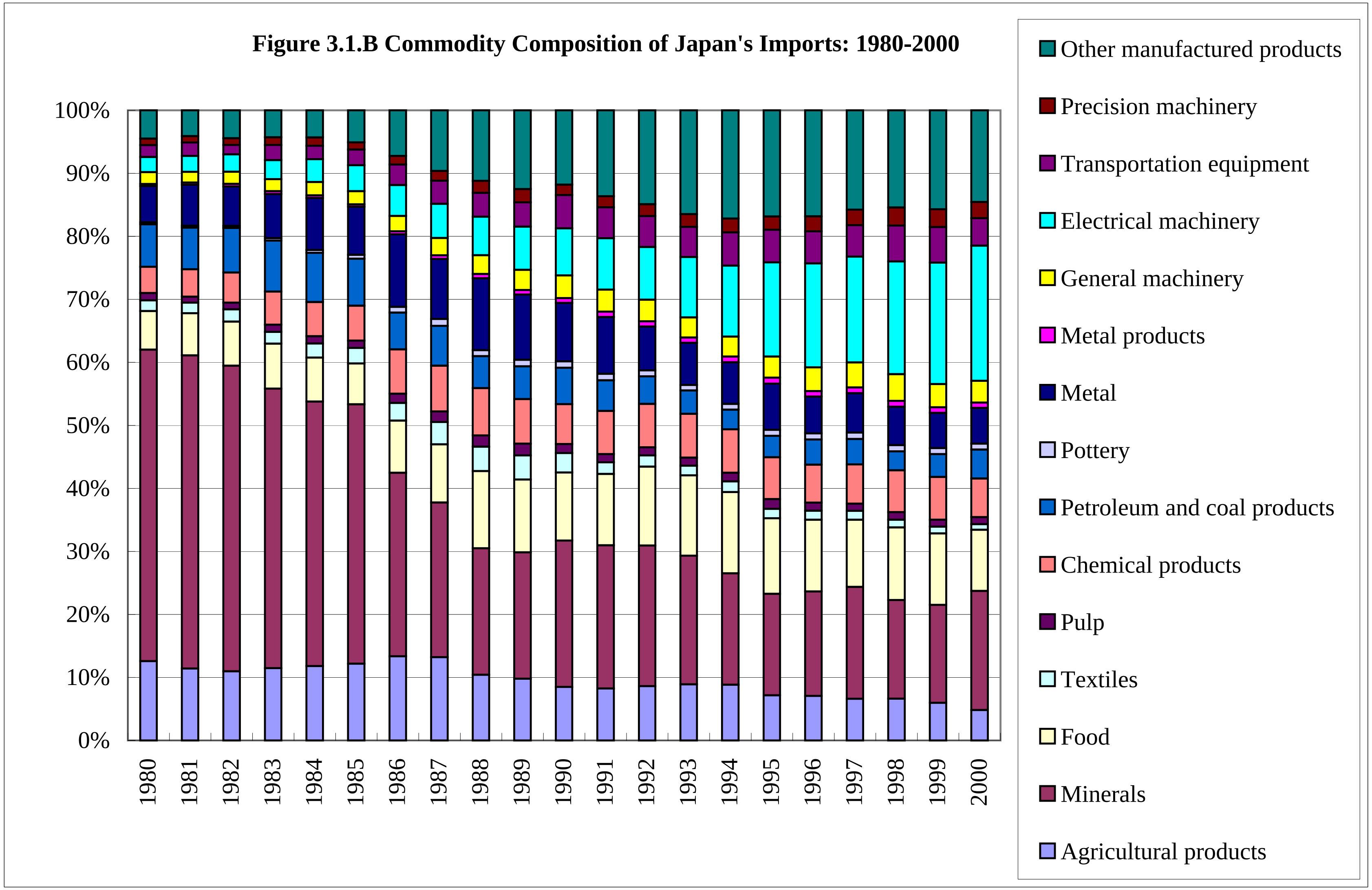
	Imports of goods and services/GDP	Imports of manufactured products (CIF)/GDP	Imports of services/GDP	Share of manufacturing sector in total GDP	Share of manufacturing sector in total employed persons	Imports of manufactured products (CIF)/gross value added by manufacturing sectoir
1980	15.1%	5.1%	1.7%	29.2%	26.2%	17.4%
1985	11.3%	4.5%	1.6%	29.5%	26.5%	15.2%
1990	9.4%	5.3%	1.6%	28.2%	26.2%	18.7%
1995	7.8%	5.0%	1.3%	24.7%	24.7%	20.3%
2000	9.5%	6.3%	1.3%	23.4%	22.3%	26.7%

Notes: Official SNA statistics for the year 2000 are based on 1993 SNA. For years before 1989, only statistics based on 1968 SNA are available. In order to make long-term comparisons we derived values for 2000 by an extrapolation based on values of 1995 and the 1995-2000 growth rate of each variable reported in SNA statistics based on 1993 SNA.

Sources: Economic and Social Research Institute, Cabinet Office, Government of Japan, *Annual Report on National Accounts 2002* , Economic Planning Agency, Government of Japan, *Annual Report on National Accounts 2000* .

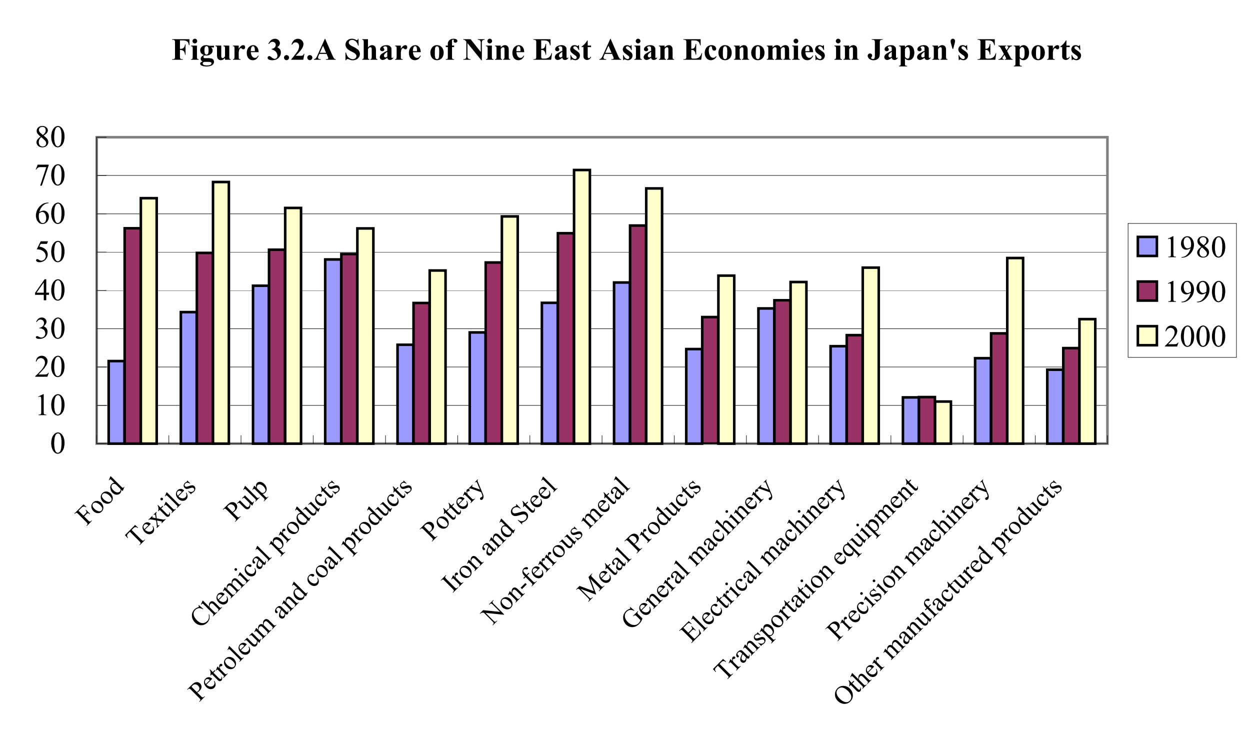


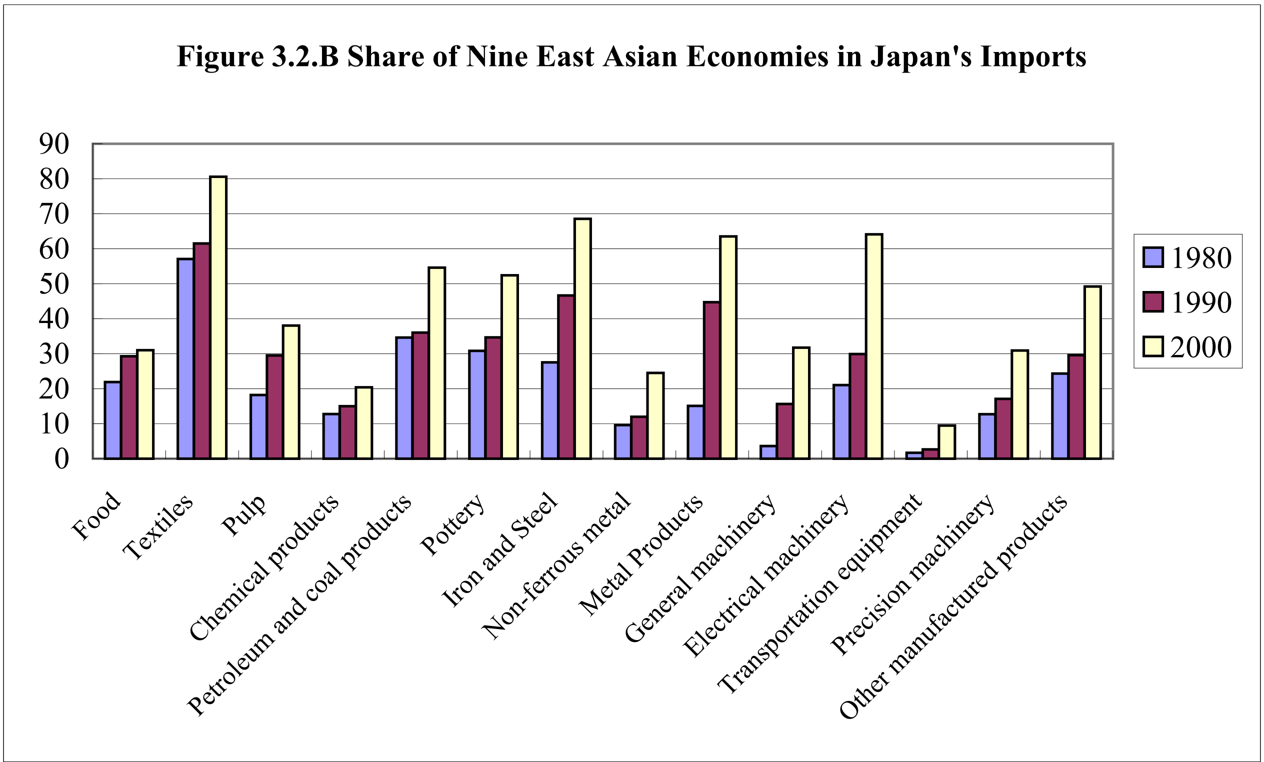
Sources: Economic and Social Research Institute, Cabinet Office, Government of Japan, *Annual Report on National Accounts 2002* ,
Economic Planning Agency, Government of Japan, *Annual Report on National Accounts 2000* .



Sources: Economic and Social Research Institute, Cabinet Office, Government of Japan, *Annual Report on National Accounts 2002* ,
Economic Planning Agency, Government of Japan, *Annual Report on National Accounts 2000* .

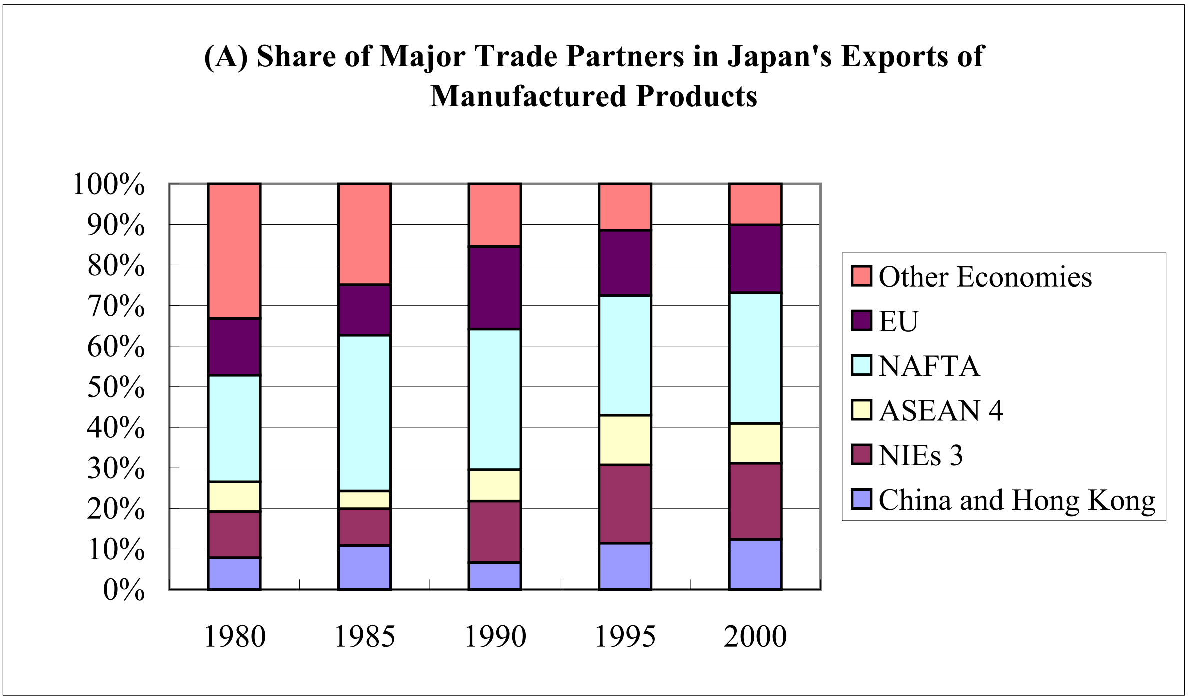
Figure 3.2 Share of Nine East Asian Economies in Japan's Trade in Manufacturing Products: 1980-2000, by Commodity

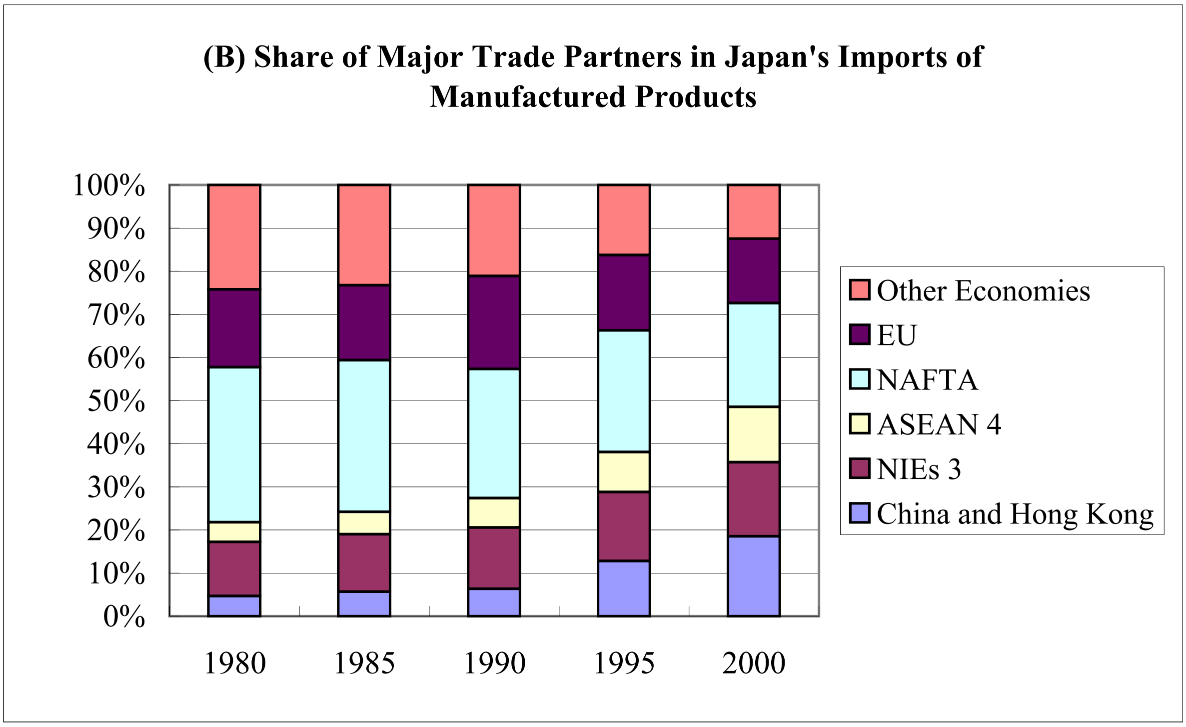




Source: Ministry of Finance, *Trade Statistics*

Figure 3.3 Japan's Major Trade Partners: Manufacturing Products, 1980-2000





Source: Ministry of Finance, *Trade Statistics*

Table 3.2 Japan's Trade in Electrical Machinery and Office Machines with China and Hong Kong in 1999

(billion yen)

Commodity classification, SITC R3	Japan's exports to China and Hong Kong (f.o.b. base)	Japan's imports from China and Hong Kong (f.o.b. base)	Japan's net-exports to China and Hong Kong
75-Office machines & automatic data processing machines	275.3	231.0	44.2
751-Office machines	173.5	117.2	56.3
752-Automatic data processing machines & units	59.0	83.7	-24.8
759-Parts of and accessories suitable for 751-752	42.8	30.1	12.7
76-Telecommunications & sound recording apparatus	316.7	302.5	14.1
761-Television receivers	37.5	39.5	-2.1
762-Radio-broadcast receivers	6.8	41.2	-34.4
763-Gramophones, dictating, sound recorders etc	n.a.	n.a.	n.a.
764-Telecommunications equipment and parts	272.4	221.8	50.6
77-Electrical machinery, apparatus & appliance	1377.9	454.2	923.7
771-Electric power machinery and parts thereof	65.7	122.7	-57.0
772-Elect.app.such as switches, relays, fuses, pl	235.2	65.9	169.4
773-Equipment for distributing electricity	48.7	63.9	-15.2
774-Electric apparatus for medical purposes	12.9	1.2	11.7
775-Household type, elect.& non-electrical equipment	14.1	52.3	-38.3
776-Thermionic, cold & photo-cathode valves, tubes	724.0	85.7	638.3
778-Electrical machinery and apparatus, n.e.s.	277.3	62.6	214.8
Total	1969.8	987.7	982.1

Source: Statistics Canada, *World Trade Analyzer 2001* .

Table 3.3 Factor Contents (Direct plus Indirect) of Trade for Japan's Manufacturing Sector: 1980-2000, by Region

Production labor	Gross exports			Gross imports			Net exports		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
World total	923,474	1,388,633	1,941,421	306,751	761,507	1,578,368	616,723	627,125	363,053
China and Hong Kong	73,317	97,278	242,423	22,976	87,209	513,402	50,341	10,070	-270,979
NIEs 3	99,132	198,831	353,213	54,302	138,387	218,617	44,830	60,444	134,596
ASEAN 4	61,937	103,502	189,007	10,060	51,945	177,053	51,877	51,557	11,953
US	223,380	440,972	583,364	90,578	178,069	273,127	132,801	262,903	310,237
EU	133,426	286,382	324,457	61,872	174,314	208,738	71,554	112,068	115,719
Other economies	332,281	261,667	248,957	66,963	131,583	187,430	265,318	130,084	61,527

Non-production labor	Gross exports			Gross imports			Net exports		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
World total	408,313	675,630	985,796	118,829	291,902	607,572	289,484	383,728	378,224
China and Hong Kong	31,756	44,161	119,781	5,861	21,364	127,705	25,895	22,797	-7,924
NIEs 3	46,089	100,185	186,061	15,805	44,569	106,804	30,285	55,617	79,257
ASEAN 4	28,616	50,583	96,495	3,679	16,693	79,591	24,937	33,890	16,904
US	96,813	215,813	294,537		87,408	136,926	54,537	128,405	157,610
EU	60,203	141,939	169,484	26,359	70,748	90,007	33,844	71,191	79,477
Other economies	144,836	122,948	119,439	24,850	51,119	66,540	119,986	71,829	52,900

Land (million yen, in 1990 prices)	Gross exports			Gross imports			Net exports		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
World total	2,367,285	3,154,935	4,251,546	782,374	1,777,449	2,895,281	1,584,911	1,377,486	1,356,265
China and Hong Kong	202,601	223,700	557,028	39,703	128,046	621,391	162,899	95,654	-64,362
NIEs 3	282,507	502,354	807,407	107,479	275,660	437,886	175,028	226,694	369,521
ASEAN 4	183,807	271,144	428,155	34,754	124,603	337,695	149,052	146,541	90,460
US	522,355	931,945	1,195,965	228,689	418,488	565,778	293,666	513,457	630,186
EU	297,871	591,223	655,089	149,588	397,799	457,527	148,284	193,424	197,562
Other economies	878,144	634,570	607,902	222,161	432,854	475,004	655,982	201,716	132,898

Capital stock (million yen, in 1990 prices)	Gross exports			Gross imports			Net exports		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
World total	11,087,602	15,378,504	21,701,611	3,068,328	7,169,480	12,586,585	8,019,274	8,209,024	9,115,026
China and Hong Kong	944,937	1,111,021	2,901,756	145,135	469,155	2,313,326	799,802	641,866	588,430
NIEs 3	1,327,911	2,442,986	4,195,098	403,842	1,113,916	2,263,765	924,069	1,329,070	1,931,333
ASEAN 4	878,622	1,312,625	2,286,969	114,037	401,754	1,552,102	764,585	910,871	734,867
US	2,479,216	4,629,732	6,052,100	975,571	1,879,475	2,710,964	1,503,645	2,750,257	3,341,137
EU	1,372,409	2,903,521	3,353,937	629,500	1,691,120	2,012,755	742,909	1,212,401	1,341,182
Other economies	4,084,507	2,978,619	2,911,750	800,244	1,614,061	1,733,673	3,284,263	1,364,559	1,178,077

Table 3.4 Changes in Factor Contents (Direct plus Indirect) of Net Exports for Japan's Manufacturing Sector: 1980-2000, by Region

Production labor

	Net exports					
	1980-90		1990-2000		1980-2000	
World total	10,403	(0.1%)	-264,073	(-3.4%)	-253,670	(-3.3%)
China and Hong Kong	-40,272	(-0.5%)	-281,049	(-3.6%)	-321,321	(-4.2%)
NIEs 3	15,614	(0.2%)	74,152	(1.0%)	89,766	(1.2%)
ASEAN 4	-320	(-0.0%)	-39,603	(-0.5%)	-39,924	(-0.5%)
US	130,101	(1.7%)	47,335	(0.6%)	177,436	(2.3%)
EU	40,513	(0.5%)	3,651	(0.0%)	44,164	(0.6%)
Other economies	-135,234	(-1.8%)	-68,557	(-0.9%)	-203,792	(-2.6%)

Non-production labor

	Net exports					
	1980-90		1990-2000		1980-2000	
World total	94,244	(2.7%)	-5,505	(-0.2%)	88,739	(2.6%)
China and Hong Kong	-3,098	(-0.1%)	-30,721	(-0.9%)	-33,819	(-1.0%)
NIEs 3	25,332	(0.7%)	23,641	(0.7%)	48,973	(1.4%)
ASEAN 4	8,953	(0.3%)	-16,986	(-0.5%)	-8,033	(-0.2%)
US	73,868	(2.1%)	29,205	(0.8%)	103,073	(3.0%)
EU	37,347	(1.1%)	8,286	(0.2%)	45,632	(1.3%)
Other economies	-48,157	(-1.4%)	-18,929	(-0.5%)	-67,087	(-1.9%)

Land (million yen, in 1990 prices)

	Net exports					
	1980-90		1990-2000		1980-2000	
World total	-207,425	(-1.6%)	-21,221	(-0.2%)	-228,646	(-1.8%)
China and Hong Kong	-67,244	(-0.5%)	-160,017	(-1.2%)	-227,261	(-1.8%)
NIEs 3	51,666	(0.4%)	142,826	(1.1%)	194,492	(1.5%)
ASEAN 4	-2,512	(-0.0%)	-56,080	(-0.4%)	-58,592	(-0.5%)
US	219,791	(1.7%)	116,729	(0.9%)	336,521	(2.6%)
EU	45,140	(0.3%)	4,138	(0.0%)	49,278	(0.4%)
Other economies	-454,267	(-3.5%)	-68,818	(-0.5%)	-523,085	(-4.1%)

Capital stock (million yen, in 1990 prices)

	Net exports					
	1980-90		1990-2000		1980-2000	
World total	189,751	(0.3%)	906,001	(1.6%)	1,095,752	(2.0%)
China and Hong Kong	-157,936	(-0.3%)	-53,436	(-0.1%)	-211,372	(-0.4%)
NIEs 3	405,001	(0.7%)	602,262	(1.1%)	1,007,263	(1.8%)
ASEAN 4	146,286	(0.3%)	-176,004	(-0.3%)	-29,718	(-0.1%)
US	1,246,611	(2.2%)	590,880	(1.1%)	1,837,492	(3.3%)
EU	469,492	(0.8%)	128,781	(0.2%)	598,273	(1.1%)
Other economies	-1,919,705	(-3.5%)	-186,482	(-0.3%)	-2,106,186	(-3.8%)

Notes: Data in parentheses denote the ratio of factor contents to total input in Japan's manufacturing sector in 1990. The data on total input are taken from the Ministry of International Trade and Industry, *Census of Manufactures 1990* .

Table 3.5 Physical and Human Capital Deepening in the Japanese Manufacturing Sector

(annual rate, %)

	1970-80	1980-90	1990-2000	1980-2000
Growth rate of capital-labor ratio				
Manufacturing sector total	11.24	6.43	5.51*	7.60**
Changes in factor contents of trade	n.a.	-0.06	0.41	0.18
Growth rate of the share of non-production workers				
Manufacturing sector total	n.a.	1.00	0.08	0.55
Changes in factor contents of trade	n.a.	0.18	0.23	0.21

*The growth rate of the capital-labor ratio denotes the average annual growth rate from 1990 to 1998.

**The growth rate of the capital-labor ratio denotes the average annual growth rate from 1980 to 1998.

Source: Authors' calculation based on the results of Tables 2.1, 2.2, and 3.4.

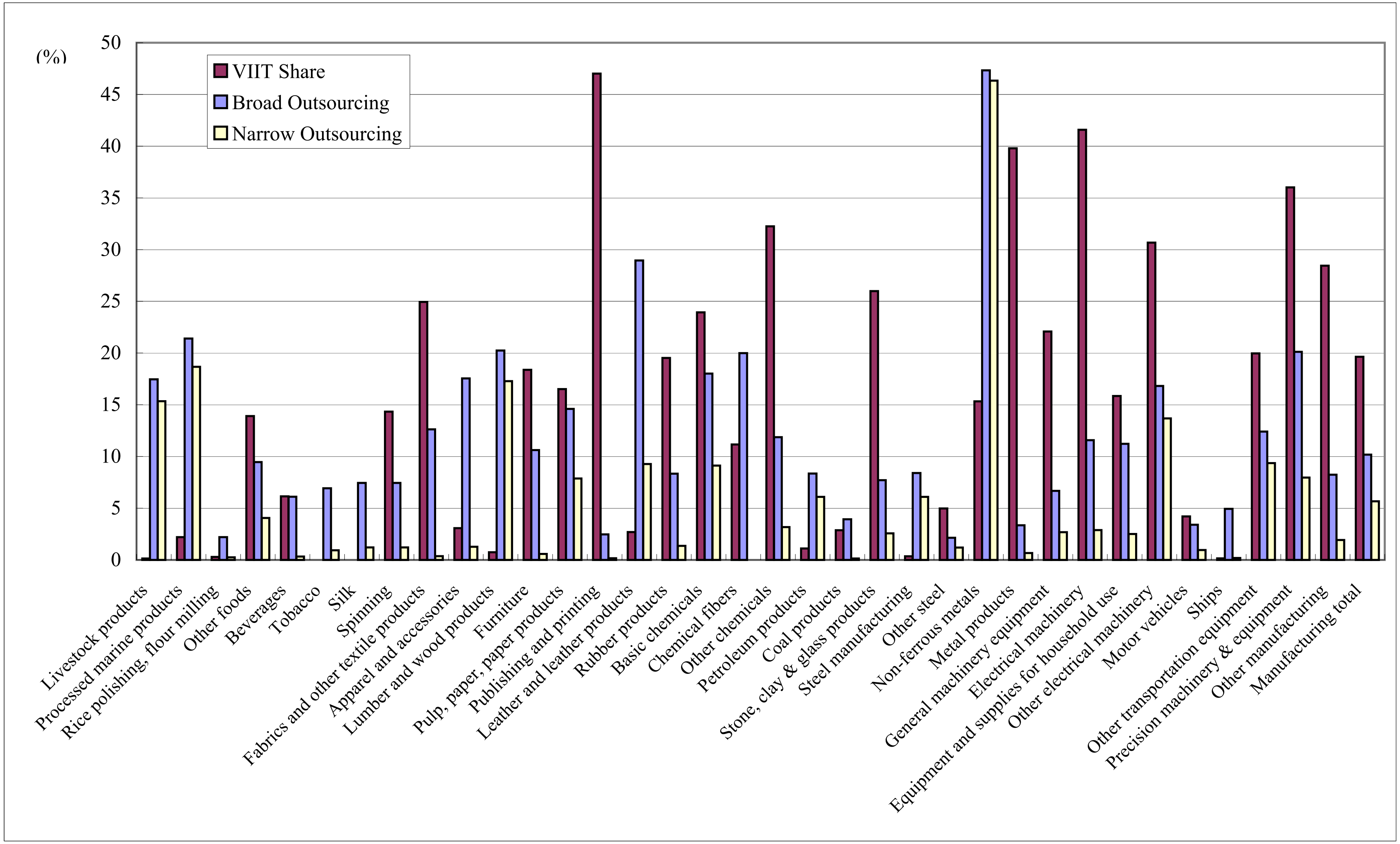
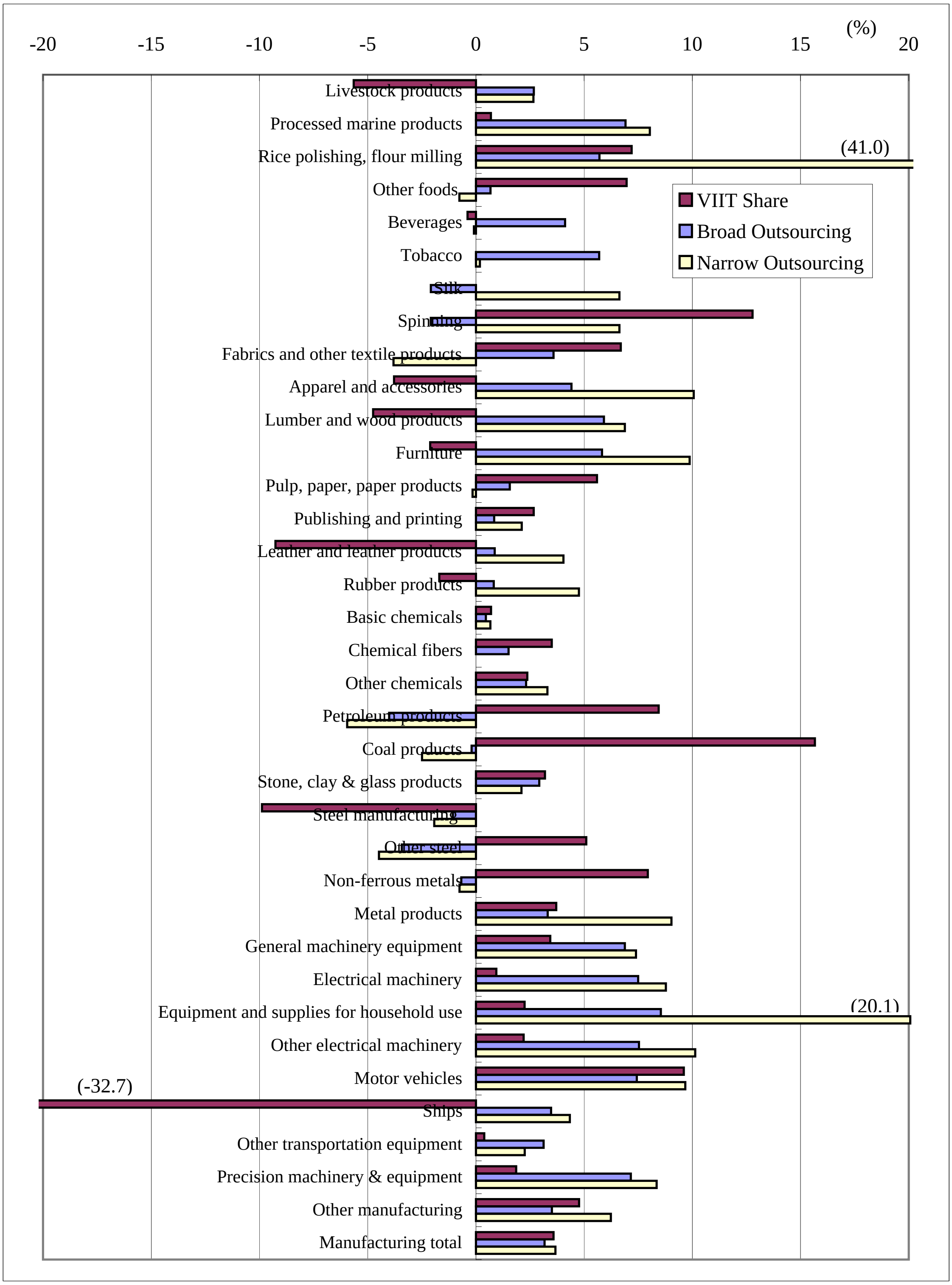


Figure 4.1 Vertical Intra-Industry Trade Share and Outsourcing Share by Industry: 2000

Source: Authors' calculation.



Growth rate of VIIT share: ƒ¢ln (VIIT/Total trade)

Growth rate of broad outsourcing share: ƒ¢ln (Broad outsourcing/Total intermediate inputs)

Growth rate of narrow outsourcing share: ƒ¢ln (Narrow outsourcing/Total intermediate inputs)

Figure 4.2 Annual Growth Rate of Vertical Intra-Industry Trade Share and Outsourcing Share by Industry: 1988-2000

Table 4.1 Correlation Coefficient Matrix

	(a) Capital-Labor Ratio	(b) Skilled Worker Share	(c) Non-production Worker Share	(d) VIIT Share	(e) Broad Outsourcing	(f) Narrow Outsourcing
(a)	1					
(b)	0.435 ***	1				
(c)	0.471 ***	0.592 ***	1			
(d)	-0.059	0.262	-0.050	1		
(e)	-0.017	0.292 *	0.210	-0.147	1	
(f)	0.146	0.299 *	0.203	0.009	0.554 ***	1

Note: Each variable denotes the average annual growth rate for the period from 1988 to 2000.
* significant at 10% level, *** significant at 1% level.
Source: Authors' calculation.

Table 4.2 GLS Estimation Results

Dependent variable:
Skilled workers' share in total number of workers (SKILLED)
Non-production workers' share in total number of workers (NONPROD)
Capital-labor ratio (KL)

	SKILLED (1)	SKILLED (2)	NONPROD (3)	NONPROD (4)	KL (5)
ln (IThard/VA)	1.4988 ***	1.3981 ***	1.7536 ***	2.0452 ***	
	(7.30)	(7.07)	(5.49)	(6.32)	
ln (ITsoft/VA)	0.0364	0.0348	-0.0509	-0.0401	
	(0.43)	(0.45)	(-0.46)	(-0.33)	
ln (NonIT/VA)	-0.7162 **	-0.5542 **	-0.5864	-0.9365 **	
	(-2.58)	(-2.02)	(-1.26)	(-2.02)	
ln VA	1.0596 ***	1.0844 ***	1.4477 ***	1.4978 ***	
	(7.20)	(6.92)	(5.17)	(6.04)	
RDexp/VA	3.0787 **	2.4287 *	3.8564 *	5.5175 **	
	(2.18)	(1.85)	(1.79)	(2.38)	
ln (wage/rental price)					-0.2732
					(-0.29)
VIITworld/Shipment	0.1521 ***		0.0351		0.2435 *
	(3.68)		(0.84)		(1.73)
VIITasia9/Shipment		0.2241 ***		0.0370	
		(3.10)		(0.24)	
VIITnon-asia/Shipment		0.0009 *		0.0005	
		(1.78)		(0.92)	
outsourcing (narrow)	0.0061	0.0033	0.0075	0.0099	-0.0018
	(0.73)	(0.44)	(0.68)	(0.83)	(-0.10)
outsourcing (difference)	-0.0320	-0.0189	-0.0315	-0.0718	-0.0196
	(-1.14)	(-0.72)	(-0.70)	(-1.45)	(-0.35)
_cons	-1.6644	-2.4111	14.4863 ***	14.8355 ***	-2.4111
	(-0.67)	(-0.94)	(3.22)	(3.61)	(-0.94)
N	439	439	439	439	385
Wald	325.60 ***	271.41 ***	187.69 ***	221.39 ***	17.51

Note: 1) Presence of AR(1) autocorrelation within panels and heteroskedasticity across panels is assumed.
2) The numbers in parentheses are z-statistics.
3) All equations include year dummies which are suppressed here. The estimation period for equations (1) to (4) is 1988-2000, and the estimation period for equation (5) is 1988-1998.
*significant at 10% level, ** significant at 5% level, ***significant at 1% level (two-tailed test).
Source: Authors' calculations.

Appendix Table 1. Occupational Classification in the *Population Census*

Major Groups

1 Professional and Technical Occupations
2 Managers and Administrators
3 Clerical and Secretarial Occupations
4 Sales Occupations
5 Services Occupations
6 Protective Service Occupations
7 Occupations in Agriculture, Forestry and Fishing
8 Occupations in Transportation and Telecommunication
9 Plant and Machine Occupations, Craft and Related Occupations, and Occupations in Mining and Construction
10 Other Occupations

Skilled workers: Groups 1 and 2
Production workers: Group 9

Appendix Table 3. Correspondence Table: Fukao-Ito Classification correspondence to 1980-85-90 Japan Linked Input-Output Standard Classification (manufacturing)

Fukao-Ito Classification	Linked I-O	Fukao-Ito Classification	Linked I-O
57 Beef meat (bone meat), Pork (born meat), Po	1111-010	112 Woven fabric apparel, Knitted apparel	1521-011
58 By-products of slaughtering and meat proces	1111-015	113 Other wearing apparel and clothing accessori	1522-011
59 Processed meat products	1112-011	114 Carpets and floor mats, Bedding, Other ready	1529-090
60 Bottled or canned meat products	1112-021	115 Timber	1611-011
61 Animal oils and fats	1112-031	116 Plywood	1611-021
62 Drinking milk	1112-041	117 Wooden chips	1611-031
63 Dairy products	1112-042	118 Wooden products for construction	1619-091
64 Frozen fish and shellfish	1113-011	119 Other wooden products, n.e.c.	1619-099
65 Salted, dried or smoked seafood	1113-021	120 Wooden furniture and fixtures, Wooden fixtu	1711-010
66 Bottled or canned seafood	1113-031	121 Metallic furniture and fixtures	1711-031
67 Fish paste	1113-041	122 Pulp, Waste paper	1811-011
68 Fish oil and meal	1113-051	123 Foreign paper and Japanese paper	1812-011
69 Other processed seafoods	1113-099	124 Paperboard	1813-011
70 Milled rice	1114-011	125 Corrugated cardboard	1813-021
71 Other grain milling	1114-019	126 Coated paper and building (construction) pap	1813-022
72 Wheat flour	1114-021	127 Corrugated card board boxes, Other paper co	1821-010
73 Other grain milled products	1114-029	128 Other pulp, paper and processed paper produ	1829-090
74 Noodles	1115-011	129 Newspapers	1911-011
75 Bread	1115-021	130 Printing, plate making and bookbinding	1911-021
76 Confectionery	1115-022	131 Publishing	1911-031
77 Bottled or canned vegetables and fruits	1116-011	132 Ammonia	2011-011
78 Preserved agricultural foodstuffs (other than l	1116-021	133 Chemical fertilizer	2011-021
79 Refined sugar	1117-011		2011-029
80 Other sugar and by-products of sugar	1117-019	134 Soda ash	2021-011
81 Starch	1117-021	135 Caustic soda	2021-012
82 Dextrose, syrup and isomerized sugar	1117-031	136 Liquid chlorine	2021-013
83 Vegetable oils, Cooking oil	1117-040	137 Other industrial soda chemicals	2021-019
84 Vegetable meal	1117-043	138 Titanium oxide	2029-021
85 Crude salt	1117-051	139 Carbon black	2029-022
86 Salt	1117-052	140 Other inorganic pigments	2029-029
87 Condiments and seasonings	1117-061	141 Compressed gas and liquified gas	2029-031
88 Prepared frozen foods	1119-011	142 Other industrial inorganic chemicals	2029-099
89 Retort foods	1119-021		2029-011
90 Dishes, sushi, lunchboxes, School lunch (pub	1119-090	143 Ethylene	2031-011
91 Refined sake	1121-011	144 Propylene	2031-012
92 Beer	1121-021	145 Other petrochemical basic products	2031-019
93 Ethyl alcohol for liquor manufacturing	1121-031	146 Pure benzene	2031-021
94 Whiskey and brandy	1121-041	147 Pure toluene	2031-022
95 Other liquors	1121-099	148 Xylene	2031-023
96 Tea and roasted coffee	1129-011	149 Other petrochemical aromatic products	2031-029
97 Soft drinks	1129-021	150 Acetic acid	2032-011
98 Manufactured ice	1129-031	151 Acetic acid vinyl monomer	2032-012
99 Feeds	1131-011	152 Styrene monomer	2032-013
100 Organic fertilizers, n.e.c.	1131-021	153 Synthetic rubber	2032-014
101 Tobacco	1141-011	154 Synthetic alcohol, Ethylene dichloride, Acryl	2032-019
102 Raw silk	1511-011	155 Methane derivatives	2039-021
103 Fiber yarns	1511-021	156 Oil and fat industrial chemicals	2039-031
	1511-031	157 Plasticizers	2039-041
	1511-041	158 Synthetic dyes	2039-051
	1511-099	159 Other industrial organic chemicals	2039-099
104 Cotton and staple fiber fabrics (inc. fabrics of	1512-011		2039-011
105 Silk and artificial silk fabrics (inc. fabrics of s	1512-021	160 Thermo-setting resins	2041-011
106 Woolen fabrics, hemp fabrics, and other fabri	1512-031	161 Thermoplastic resin, Polyethylene (low densi	2041-091
	1512-091	162 High functionality resins	2041-092
	1512-099	163 Other resins	2041-099
107 Knitting fabrics	1513-011	164 Rayon, acetate	2051-011
108 Yarn and fabric dyeing and finishing (proces	1514-011	165 Synthetic fibers	2051-021
109 Rope and nets	1519-011	166 Medicaments	2061-011
110 Fabricated textiles for medical use	1519-031	167 Soap and synthetic detergents, Surface active	2071-010
111 Other fabricated textile products	1519-099	168 Cosmetics, toilet preparations and dentifrices	2071-021

(continued)

169	Paints and varnishes	2072-011
170	Printing ink	2072-021
171	Photographic sensitive materials	2073-011
172	Agricultural chemicals	2074-011
173	Gelatin and adhesives, Other final chemical p	2079-011
		2079-090
174	Gasoline	2111-011
175	Jet fuel oils	2111-012
176	Kerosene	2111-013
177	Light oils	2111-014
178	Heavy oil A	2111-015
179	Heavy oils B and C	2111-016
180	Naphtha	2111-017
181	LPG (Liquified Petroleum gas)	2111-018
182	Other petroleum refinery products	2111-019
183	Coke	2121-011
184	Other coal products	2121-019
185	Paving materials	2121-021
186	Plastic films and sheets, Plastic plates, pipe a	2211-010
187	Tires and inner tubes	2311-011
188	Other rubber products	2311-019
189	Rubber footwear	2319-011
190	Plastic footwear	2319-021
191	Leather footwear	2411-011
192	Leather and fur skins	2412-011
193	Miscellaneous leather products	2412-021
194	Sheet glass, Safety glass and multilayered gla	2511-010
195	Glass processing materials, Other glass produ	2519-090
196	Cement	2521-011
197	Ready mixed concrete	2522-011
198	Cement products	2523-011
199	Pottery, china and earthenware for constructi	2531-011
200	Pottery, china and earthenware for industry	2531-012
201	Pottery, china and earthenware for home use	2531-013
202	Clay refactories	2599-011
203	Other structural clay products	2599-021
204	Carbon and graphite products	2599-031
205	Abrasive	2599-041
206	Miscellaneous ceramic, stone and clay produ	2599-091
		2599-099
207	Pig iron	2611-011
208	Ferroalloys	2611-021
209	Crude steel (converters), Crude steel (electric	2611-030
210	Scrap iron	2612-011
211	Steel, Steel strip (ordinary steel), Steel bar (o	2621-010
212	Hot rolled steel (special steel)	2621-016
213	Steel pipes and tubes (ordinary steel)	2622-011
214	Steel pipes and tubes (special steel)	2622-012
215	Cold-finished steel	2623-011
216	Coasted steel	2623-012
217	Forged steel	2631-011
218	Cast steel	2631-012
219	Case iron pipes and tubes	2631-021
220	Case materials (iron)	2631-031
221	Forged materials (iron)	2631-032
222	Iron and steel shearing and slitting, other iron	2649-090
223	Copper	2711-011
224	Lead and Zinc (inc. regenerated lead)	2711-021
		2711-031
225	Aluminum (inc. regenerated lead)	2711-041
226	Other non-ferrous metals	2711-099
227	Non-ferrous metal scrap	2712-011
228	Electric wires and cables, Optical fiber cables	2721-010
		2721-012
229	Rolled and drawn copper and copper alloys	2722-011
230	Rolled and drawn aluminum	2722-021
231	Non-ferrous metal castings and forgings	2722-031
232	Nuclear fuels	2722-041
233	Other non-ferrous metal products	2722-099
234	Metal Products for Construction	2811-011
235	Metal Products for Architecture	2812-011
236	Other metal Products, n.e.c.	2899-090
237	Boilers, Turbines, Engines	3011-010
238	Conveyors	3012-011
239	Refrigerators and Air Conditioning Apparatu	3013-011
240	Pumps and Compressors	3019-011
241	Other General industrial machinery and equip	3019-090
242	Mining, Civil engineering and Construction M	3021-011
243	Chemical machinery	3022-011
244	Metal Machine Tools	3024-011
245	Metal Processing Machinery	3024-021
246	Agricultural machinery	3029-011
247	Textile Machinery	3029-021
248	Food Processing Machinery	3029-031
249	Sawmill, Wood Working, Veneer and Plywoo	3029-091
250	Pulp, Equipment and Paper Machinery	3029-092
251	Printing, Bookbinding and Paper Processing	3029-093
252	Casting Equipment	3029-094
253	Plastic Processing Machinery	3029-095
254	Semiconductor Making Equipment, Other Sp	3029-099
255	Machinists' precision tools, Metal molds, Bea	3019-021
		3031-090
256	Copy Machine, Electronic Calculator, Word I	3111-010
257	Vending Machines	3112-011
258	Amusement Machinery	3112-012
259	Other Machinery for Service Industry	3112-019
260	Electric Audio Equipment, Magnetic Tapes a	3211-010
261	Radio and Television sets	3211-021
262	Household Electric Appliance	3211-099
263	Electric Computing Equipment (Main Parts, A	3311-010
264	Wired Communication Equipment, Radio Co	3321-010
265	Video Recording and Playback Equipment	3331-010
266	Electric Measuring Instruments	3332-011
267	Semiconductor Devices, Integrated Circuits	3341-010
268	Electron Tubes	3359-011
269	Generators	3411-011
270	Electric Motors	3411-012
271	Relay Switches and Switchboards, Transform	3411-020
272	Electric Lighting Fixtures and Apparatus	3421-011
273	Electric Bulbs	3421-031
274	Batteries, Wiring Devices and Supplies, Elec	3421-090
275	Passenger Motor Cars	3511-011
276	Trucks, Buses and Other Cars, Motor Vehicle	3511-019
277	Two-wheel Motor Vehicles	3531-011
278	Internal Combustion Engines for Motor Vehi	3541-021
279	Steel Ships	3611-011
280	Ships Except Steel Ships	3611-021
281	Internal Combustion Engines for Vessels	3611-031
282	Repair of Ships	3611-101
283	Rolling Stock	3621-011
284	Repair of Rolling Stock	3621-101
285	Aircrafts	3622-011
286	Repair of Aircrafts	3622-101
287	Bicycles	3629-011

(continued)

288	Transport Equipment for Industrial Use	3629-091
289	Other Transport Equipment, n.e.c.	3629-099
290	Camera	3711-011
291	Other Photographic and Optical Instruments	3711-099
292	Watches and Clocks	3712-011
293	Professional and Scientific Instruments	3719-011
294	Analytical Instruments, Testing Machine, Me	3719-021
295	Medial Instruments	3719-031
296	Toys, Sporting and Athletic Goods	3911-010
297	Musical Instruments, Audio and Video Recor	3919-010
298	Writing Instruments and Stationery	3919-031
299	Small Personal Adornments	3919-041
300	"Tatami" (Straw Matting) and Straw Product:	3919-051
301	Ordnance	3919-061
302	Miscellaneous Manufacturing Products	3919-099

Appendix Table 4. Correspondence Table
--- JIP Classification correspondence to Fukao-Ito Classification (manufacturing)---

JIP Industry	Fukao-Ito Classification									
11 Livestock products	57	58	59	60	61	62	63			
12 Processed marine products	64	65	66	67	68	69				
13 Rice polishing, flour milling	70	71	72	73						
14 Other foods	74	75	76	77	78	79	80	81	82	83
	84	85	86	87	88	89	90	99	100	
15 Beverages	91	92	93	94	95	96	97	98		
16 Tobacco	101									
17 Silk	102									
18 Spinning	103									
19 Fabrics and other textile products	104	105	106	107	108	109	110	111		
20 Apparel and accessories	112	113	114							
21 Lumber and wood products	115	116	117	118	119					
22 Furniture	120	121								
23 Pulp, paper, paper products	122	123	124	125	126	127	128			
24 Publishing and printing	129	130	131							
25 Leather and leather products	191	192	193							
26 Rubber products	187	188	189	190						
27 Basic chemicals	132	133	134	135	136	137	138	139	140	141
	142	143	144	145	146	147	148	149	150	151
	152	153	154	155	156	157	158	159	160	161
	162	163								
28 Chemical fibers	164	165								
29 Other chemicals	166	167	168	169	170	171	172	173		
30 Petroleum products	174	175	176	177	178	179	180	181	182	
31 Coal products	183	184	185							
32 Stone, clay & glass products	194	195	196	197	198	199	200	201	202	203
	204	205	206							
33 Steel manufacturing	207	208	209	210						
34 Other steel	211	212	213	214	215	216	217	218	219	220
	221	222								
35 Non-ferrous metals	223	224	225	226	227	228	229	230	231	232
	233									
36 Metal products	234	235	236							
37 General machinery equipment	237	238	239	240	241	242	243	244	245	246
	247	248	249	250	251	252	253	254	255	256
	257	258	259	278	281					
38 Electrical machinery	269	270	271							
39 Equipment and supplies for household use	260	261	262							
40 Other electrical machinery	263	264	265	266	267	268	272	273	274	
41 Motor vehicles	275	276								
42 Ships	279	280	282							
43 Other transportation equipment	277	283	284	285	286	287	288	289		
44 Precision machinery & equipment	290	291	292	293	294	295				
45 Other manufacturing	186	296	297	298	299	300	301	302		