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1

Physical and Human Capital Deepening and New Trade Patterns in Japan

Keiko Ito and Kyoji Fukao

1.1 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 U.S. economy (Jorgenson, Ho, and Stiroh 2002) with those for the Japanese economy (Fukao, Inui, Kawai, and Miyagawa 2004). We can see that, compared with the United States, 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.

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 steadily declined. Comparing South Korea and Japan with other Organization for Economic Cooperation and Development (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. Looking at human capital, Katz and

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Table 1.1 Sources of economic growth: U.S.–Japan comparison (annual rate, %)

	Real GDP growth (a)	Man-hour growth (b)	Labor productivity (GDP/man-hour) growth (c) = (a) – (b)	TFP growth (d) = (c) – (e) – (f)	Contribution of labor quality growth (e)	Contribution of capital services/man-hour growth: Subtotal (f) = (g) + (h)	Contribution of capital services/man-hour growth: Contribution of IT capital (g)	Contribution of capital services/man-hour growth: Contribution of non-IT capital (h)
A. The result of growth accounting for the U.S. economy: 1973–2000[a]								
1973–95	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
B. The result of growth accounting for the Japanese economy: 1973–98[b]								
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

[a] Jorgenson et al. (2002).
[b] Fukao et al. (2004), table 6.2.

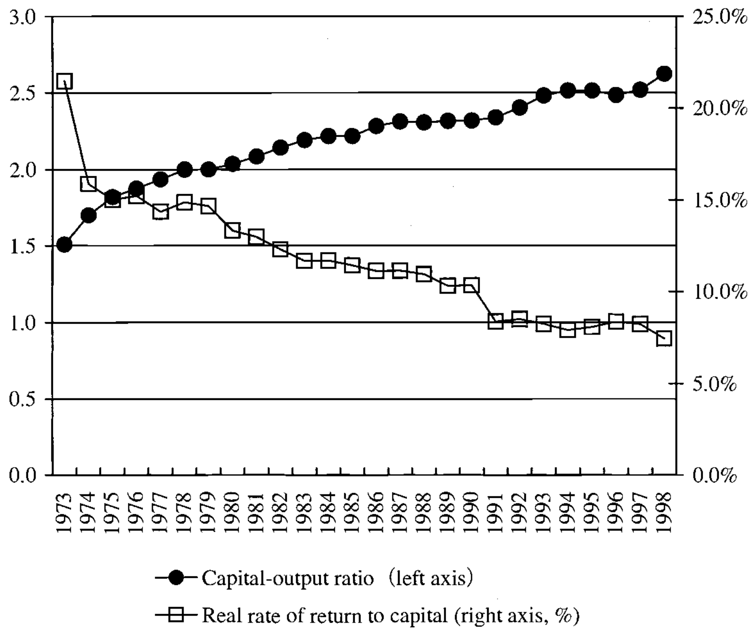


Fig. 1.1 Japan's capital-output ratio and rate of return to capital: 1973–1998
Source: JIP database.
Note: The numerator of the rate of return to capital is the surplus of the national accounts deflated by the gross domestic product (GDP) deflator.

Revenga (1989) found that while educational earning differentials expanded drastically in the United States in the 1980s, the college wage premium in Japan increased only slightly. As Genda (1998) showed, the underlying reason is that the employment of skilled workers, such as older male college graduates, expanded rapidly in Japan, resulting in an excess supply of skilled workers relative to the number of available management positions that contributed to the stagnation of earnings for older college graduates. Probably partly as a result of this decline in the rates of return, the accumulation of physical and human capital has slowed down over the past decade (table 1.1).[1]

We should note that according to standard trade theory, rapid growth based on capital accumulation is 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 effect of diminishing rates of return to physical and human capital.

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

For Japan, the 1990s were an age of "globalization" marked by a deepening of the international division of labor, especially with other East Asian countries: not only did international trade and direct investment flourish, there has also been a marked change in the commodity composition of both imports and exports, and East Asia has overtaken North America as the most important origin and destination of Japan's trade. Trade theory suggests that this deepening of the international division of labor would lead Japan to further specialize in physical and human capital–intensive products and to outsource unskilled labor–intensive products to other East Asian countries, and these changes in trade patterns should affect the ratio of wages to the rental prices of capital and the ratio of skilled labor wages to unskilled labor wages. The purpose of this paper is to examine this deepening of the international division of labor since the 1980s and to evaluate how much of the diminishing rate-of-return effect 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 intraindustry trade (i.e., intraindustry trade where goods are differentiated by quality) between developed and developing economies may have boosted the vertical division of labor within industries. This type of international division of labor would cause a deepening of the physical and human capital within each industry in developed economies. However, as the resulting capital deepening will occur within each industry, we cannot correctly analyze this type of division of labor by using interindustry trade data. Consequently, we study the international division of labor by looking at both interindustry trade and intraindustry trade.

The remainder of the paper is organized as follows. In section 1.2, we examine physical and human capital deepening in Japan. In section 1.3, we take a broad look at Japan's interindustry trade and factor contents in order to measure to what extent Japan's capital deepening is offset by international trade. In section 1.4, after providing an overview of the changes in Japan's intraindustry 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 1.5 presents our conclusions.

1.2 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 macroeconomic 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 nonproduction 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 nonproduction (or skilled) workers in the manufacturing sector and the Japanese economy as a whole. As figure 1.2 shows, the capital-labor ratio measured as real capital stock (in 1990 prices) 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 fivefold from three million yen per person in 1970 to 15 million yen per person in 1998.

In order to examine human capital deepening in Japan, we compiled data on the number of nonproduction 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 “nonproduction 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; service occupations; protective occupa-

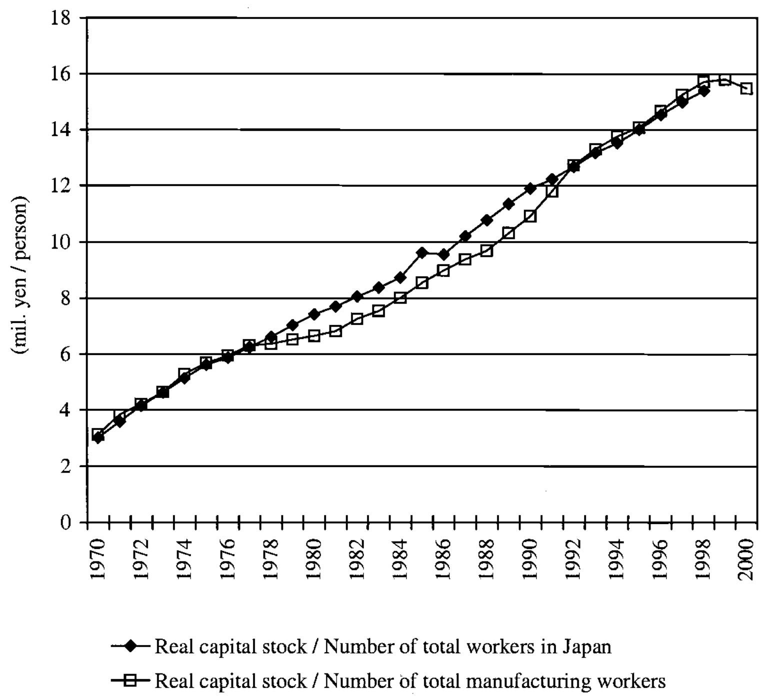


Fig. 1.2 Trend of capital-labor ratio in Japan

Source: Authors’ calculation based on the JIP database.

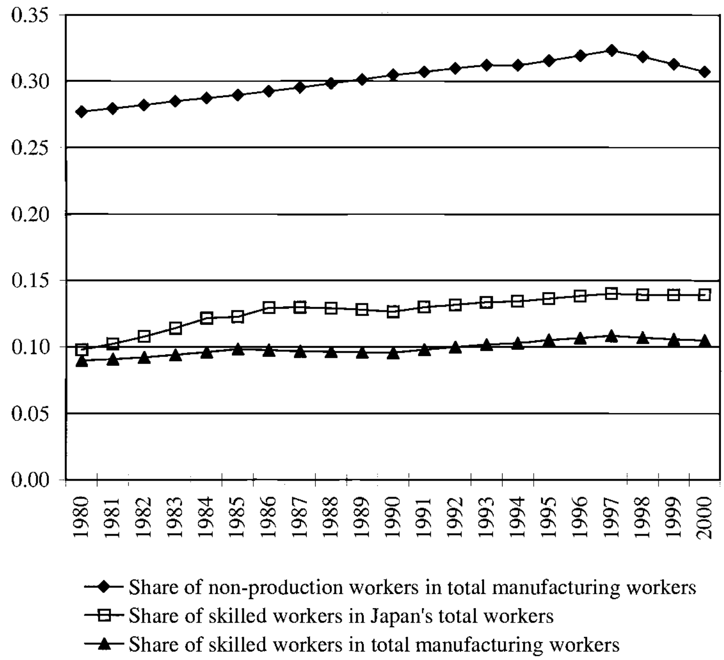


Fig. 1.3 Share of skilled and nonproduction workers in total workers
Source: Authors' calculation based on *Population Census* data.

tions; occupations in agriculture, forestry, and fishing; occupations in transportation and telecommunications; and other occupations. The definition of nonproduction workers is much broader than the definition of "skilled workers" and includes not highly educated workers. The share of nonproduction (or skilled) workers in the total number of workers has been increasing, as shown in figure 1.3, though the growth rate is much more moderate than that of the capital-labor ratio. In the period from 1980 to 2000, the share of nonproduction workers in manufacturing increased from 27.7 percent in 1980 to 30.7 percent in 2000.[2] The share of skilled workers also grew during 1980–2000: in the manufacturing sector, it rose from 9.0 percent to 10.5 percent, while in the economy as a whole it expanded from 9.8 percent to 13.9 percent.[3]

The increase in the capital-labor ratio and in the share of nonproduction (or skilled) workers can be decomposed into the contribution of the increase within each industry (within effect) and the contribution of the re-

2. This latter value, though, is substantially below the peak of 32.3 percent reached in 1997. The decline in the share of nonproduction workers since 1998 is most likely the result of firms' restructuring efforts—the dismissal of managers, sales personnel, and so on—following the further deterioration of the Japanese economy.

3. For details on the compilation of the skilled/nonproduction workers data, see appendix.

allocation between industries (between effect) using the following decomposition formula:

$$\Delta P = \sum_{i=1}^{n} \overline{S_i} \Delta P_i + \sum_{i=1}^{n} \overline{P_i} \Delta S_i$$

i: industry ($i = 1, 2, \ldots, n$)

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

$P_i = \frac{K_i}{L_i}$: capital-labor ratio in industry i, or

$= \frac{L_{si}}{L_i}$: share of nonproduction (or skilled) workers in total number of workers in industry i

$S_i = \frac{L_i}{L}$: 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 over time. 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 highly disaggregated cross-industry data available for our decomposition analysis. Unfortunately, such data were unavailable, so we had to use the relatively aggregated data of the JIP database.[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 1.2 and 1.3. As for the growth in the capital-labor ratio, the decomposition provided in table 1.2 shows that there was a negative between effect in most periods between 1970 and 1998, thus providing evidence for the decline of the capital-intensive sectors of the economy. Moreover, the magnitude of the between effect is very small throughout the entire period, and most of the growth in the capital-labor ratio is attributable to the within effect. In contrast, the decomposition of the growth of the share of skilled or nonproduction workers presented in table 1.3 shows that here the between effect was positive in all cases, indicating that the share of human capital–intensive industries has increased steadily both in the manufacturing sector and in the economy as a whole. The within effect was also positive with the ex-

4. In the following decomposition, we used data of thirty-five manufacturing industries and forty-three nonmanufacturing industries.

Table 1.2 **Decomposition of capital-labor ratio growth (annual rate, %)**

	1970–80	1980–90	1990–2000	1980–2000
A. Decomposition of capital-labor ratio growth: Manufacturing sector				
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
	1970–80	1980–90	1990–98	1980–98
B. Decomposition of capital-labor ratio growth: The whole economy				
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

Source: Authors' calculation based on the JIP database.

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

Table 1.3 **Decomposition of the growth of the share of skilled or nonproduction workers (annual rate, %)**

	1980–90	1990–2000	1980–2000
A. Decomposition of the growth of the share of nonproduction workers: Manufacturing sector			
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
B. Decomposition of the growth of the share of skilled workers: Manufacturing sector			
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
C. Decomposition of the growth of the share of skilled workers: The whole economy			
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.

ception of two cases in the period of 1990–2000, and it was always greater than the between effect except for these two cases.

The most important implication of these results is that the within effect is very large. Some part of this within effect may have been caused by the international division of labor within each industry. We analyze this issue in section 1.4.

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 within effect during the period 1990–2000 for the share of nonproduction 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 interindustry trade, which affects the size of each industry in Japan, while the within-industry shift may be explained by the change in patterns of intraindustry 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.

1.3 Japan's Interindustry Trade and Factor Contents

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

1.3.1 Overview of Japan's International Trade

Although Japan's overall import–gross domestic product (GDP) ratio has gradually declined over the last two decades, imports of manufactured products have actually grown faster than the economy as a whole (see table 1.4). According to Japan's trade statistics, the increase in imports mainly concentrated on electrical machinery and labor intensive goods, such as apparel and wooden products. Because 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 percent in 1985 to 26.7 percent in 2000 (table 1.4).[5]

The commodity composition of Japan's exports at the two-digit level has remained relatively stable over the last fifteen years. 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]

What is more, along with the change in the commodity composition,

5. The United States experienced a similar trend during the 1980s, when this ratio jumped by 12.4 percentage points from 18.3 percent in 1978 to 30.7 percent in 1990 (Sachs and Shatz 1994). Comparing export shares and import penetration in the United States, Canada, the United Kingdom, and Japan during the period 1974–1993, 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 today using more recent data, we would probably reach a different conclusion.

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

Table 1.4 Japan's share of imports and the manufacturing sector in GDP, employment, and gross value added (%)

	Imports of goods and services/GDP	Imports of manufactured products (c.i.f.)/GDP	Imports of services/GDP	Share of manufacturing sector in total GDP	Share of manufacturing sector in total employed persons	Imports of manufactured products (c.i.f.)/gross value added by manufacturing sector
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

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.*

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. c.i.f. = cost plus insurance and freight.

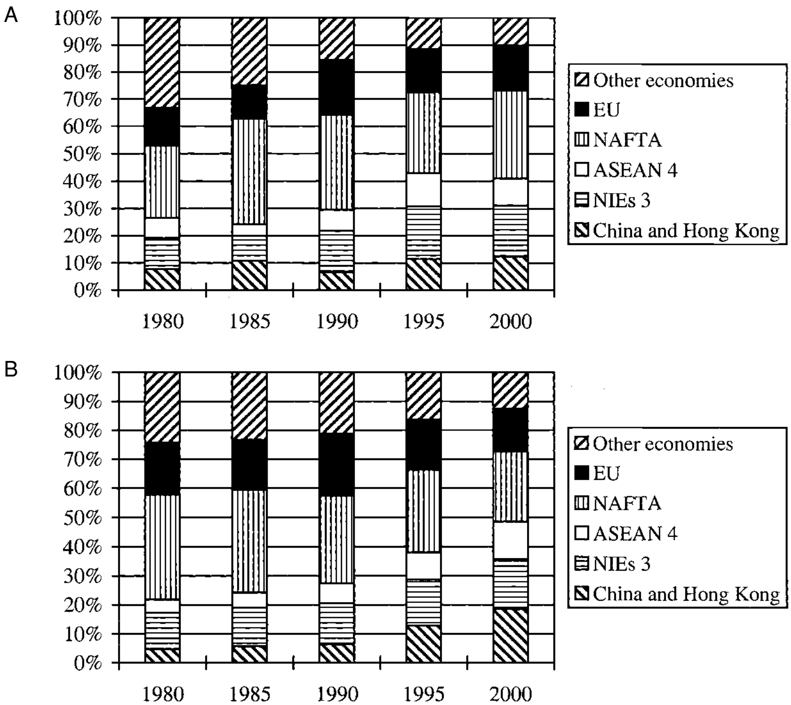


Fig. 1.4 Japan's major trade partners: Manufacturing products, 1980–2000: *A,* Share of major trade partners in Japan's exports of manufactured products; *B,* Share of major trade partners in Japan's imports of manufactured products
Source: Ministry of Finance, *Trade Statistics.*

there has been a shift in the regional composition of Japan's trade, with East Asia replacing North America as the most important region for the country's exports and imports. As figure 1.4 shows, trade with nine East Asian economies (China, Hong Kong, Taiwan, Korea, Singapore, Indonesia, Thailand, the Philippines, and Malaysia) accounted for 48.5 percent of Japan's total manufactured imports and 41.0 percent of total manufactured exports in 2000.

The increase in the nine East Asian economies' share in Japan's exports and imports extends across almost all manufacturing industries, suggesting that there has been a significant rise in two-way trade between Japan and the East Asian economies (see figure 1.5). Particularly conspicuous is the jump of these economies' share in Japan's electrical machinery imports between 1990 and 2000. A large rise can also be observed in many labor intensive products, which in this figure are classified as "other manufactured products" or "pottery." As a result, by 2000, the nine East Asian economies provided 64.2 percent of Japan's electrical machinery imports and 49.2

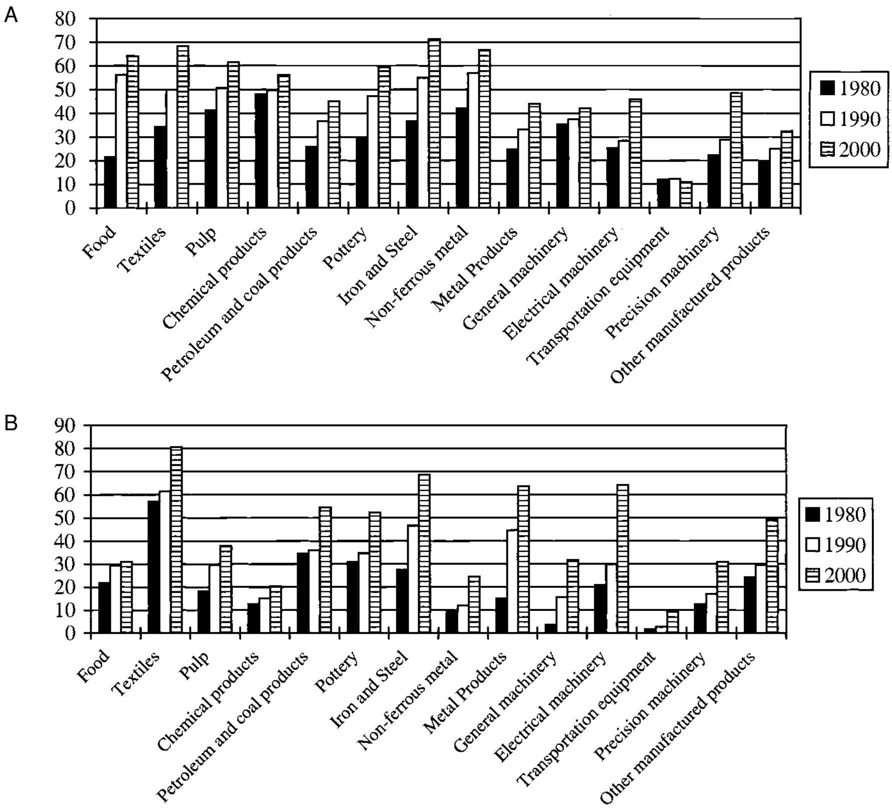


Fig. 1.5 Share of the nine East Asian economies in Japan's trade in manufacturing products: 1980–2000, by commodity: *A*, Share of the nine East Asian economies in Japan's exports; *B*, Share of the nine East Asian economies in Japan's imports

Source: Ministry of Finance, *Trade Statistics.*

Note: The nine East Asian economies are China, Hong Kong, Taiwan, Korea, Singapore, Indonesia, Thailand, the Philippines, and Malaysia.

percent of Japan's imports of "other manufacturing products." The East Asian economies' share in Japan's total imports of machinery and intermediate products such as metal products and chemical products also increased rapidly. On the export side, the increase in the East Asian economies' share in the 1990s was particularly pronounced in the electrical machinery and precision machinery sectors.

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. However, how can we interpret the rapid expansion in the two-way trade within many industries? As an illustration, let us look at Japan's bilateral trade in electrical machinery (at the three-digit level) with China and Hong Kong in 1999. This is where the conspicuous increase in two-way trade in recent years has been concentrated, and the patterns that can be observed provide a clue to answering the preceding question.

These patterns are shown in table 1.5 and point at two important facts. First, they suggest a division of labor within the electrical machinery industry: vis-à-vis 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) but a net exporter of other, more technology-intensive 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 thirty-seven times greater than the trade balance. It seems that we need to analyze intraindustry trade in order to correctly evaluate the impact of trade on the Japanese economy. We do this in section 1.4.

1.3.2 Factor Contents in Japan's Trade in 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 Manufacturers.* The data are classified by the four-digit Standard Industrial Classification for Japan, which listed 540 manufacturing industries in 1990.

There is no direct converter between this industry classification and the nine-digit Harmonized Commodity Description and Coding System (HS) classification used by the Ministry of Finance for the compilation of Japan's international trade statistics. In order to link the two data sets—on factor requirements and on 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 the supplementary converter tables

7. Using the Management and Coordination Agency of the Japanese Government's "1980-85-90 Linked Input-Output Tables," Sakurai (2004) estimated factor contents in Japan's trade for the years 1980, 1985, and 1990.

Table 1.5 **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 and automatic data processing machines	275.3	231.0	44.2
751 Office machines	173.5	117.2	56.3
752 Automatic data processing machines and units	59.0	83.7	–24.8
759 Parts of and accessories suitable for 751–752	42.8	30.1	12.7
76 Telecommunications and 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, and appliances	1,377.9	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, plugs	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. and nonelectrical equipment	14.1	52.3	–38.3
776 Thermionic, cold and 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	1,969.8	987.7	982.1

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

Notes: n.a. = not available. n.e.s. = not elsewhere specified.

of the input-output (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] However, because inverse matrix coefficients were available for only 103 manufacturing industries, we reclassified the data for 246 manufacturing industries into 103 manufacturing industries. Then we estimated direct and indirect factor requirements using the corresponding I-O table.

Ideally, we would use up-to-date factor requirement data and I-O tables in order to take changes in production technologies into account. Unfortunately, data on the factor requirements for production and nonproduction workers are available only until 1990 because the *Census of Manufacturers* 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

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

where ($K \times 1$) vector $\mathbf{X}_t = [x_{k,t}]$ denotes the total contents of factor k in Japan's trade of year t. ($K \times J$) matrix $\mathbf{D} = [d_{k,j}]$ denotes the quantity of primary factor k directly used per unit of output in industry j in year 1990. ($J \times J$) matrix $\mathbf{A}$ is the input-output matrix of year 1990.[10] ($J \times 1$) vector $\mathbf{T}_t$ 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 Tables* and the *Wholesale Price Index* of the Bank of Japan at the three-digit level.[11]

We analyzed factor content in terms of the following four primary factors: physical capital (book value), production labor (number of workers),

8. The factor requirement data of the *Census of Manufacturers* are on an establishment basis, and each establishment is classified by its most important product. Because many establishments produce various commodities simultaneously, this classification method is problematic. The I-O converter from the *Census of Manufacturers* 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 trade in recent years in the case of industries where total factor productivity has grown rapidly.

10. The I-O matrix here covers only manufacturing industries. Therefore, our analysis does not include indirect factor requirements through changes in production in nonmanufacturing industries.

11. The conversion of trade statistics at the HS nine-digit level into trade data 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 (2004).

nonproduction labor (number of workers), and land (book value).[12] 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 (a) China and Hong Kong; (b) the newly industrialized economies (NIEs)-3 (Taiwan, South Korea, and Singapore); (c) the Association of Southeast Asian Nations (ASEAN)-4 (Indonesia, Thailand, Malaysia, and the Philippines); (d) the United States; (e) the European Union (EU); and (f) all other economies.

The results of the factor content analysis for the years 1980, 1990, and 2000 are reported in table 1.6. 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 percent 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 percent. This decline was almost entirely caused by Japan's trade with China and Hong Kong (see table 1.7). In the year 2000, about one-third of factor content gross imports of production workers came from China and Hong Kong (table 1.6).

In the case of nonproduction workers, there were factor content net exports of 378,000 nonproduction workers in the year 2000, which represents 10.9 percent of the total of nonproduction workers (3,456,000) in manufacturing in 1990. Compared with trade patterns in 1980, net exports of nonproduction workers have increased by 89,000, which is equivalent to 2.6 percent of the total of nonproduction workers in 1990. The major increase in this factor content occurred in Japan's trade with the United States (table 1.7).

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 percent 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 1.7).

Capital stock factor content net exports in 2000, meanwhile, stood at 9.12 trillion yen (in 1990 prices), which represents 16.5 percent of the total capital stock (55.4 trillion yen) in manufacturing in 1990. Compared with 1980, this represents an increase in net exports of capital stock by 1.1 trillion yen or 2.0 percent of the total capital stock in 1990 (table 1.7).

12. Ideally we would use the real values of physical capital and land stocks instead of the book values. However, we chose to use the book values because it is difficult to obtain capital stock and land stock deflators at such a detailed industry level. While it would be possible to roughly estimate the ratio of real value to book value of physical capital stock by utilizing various survey data on capital stocks, it would be extremely difficult to estimate the real value of land due to data constraints and the volatility of land prices.

Table 1.6 Factor contents (direct plus indirect) of trade for Japan's manufacturing sector: 1980–2000, by region

	Gross exports			Gross imports			Net exports		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
				Production labor					
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
U.S.	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
				Nonproduction labor					
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
U.S.	96,813	215,813	294,537	42,276	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

(*continued*)

Table 1.6 (continued)

	Gross exports			Gross imports			Net exports		
	1980	1990	2000	1980	1990	2000	1980	1990	2000
				Land (million yen, in 1990 prices)					
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
U.S.	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)					
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
U.S.	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

Source: Authors' calculation.

Table 1.7 **Changes in factor contents (direct plus indirect) of net exports for Japan's manufacturing sector: 1980–2000, by region**

	Net exports		
	1980–90	1990–2000	1980–2000
	Production labor		
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)
U.S.	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)
	Nonproduction labor		
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)
U.S.	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)		
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)
U.S.	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)		
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)
U.S.	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)

Source: Authors' calculation.

Notes: Data in parentheses (percentages) 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 Manufacturers 1990.*

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

As table 1.7 shows, in the period from 1980 to 2000, Japan's factor content net exports of production workers fell by 3.3 percent, while net exports of nonproduction workers rose by 2.6 percent. This change in trade patterns has the effect of increasing the implied supply ratio of production/nonproduction workers available to the manufacturing sector for other use by about 5.9 percent. More than one-half of this change (3.2 percent) 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 percent, while net exports of workers overall (production and nonproduction) decreased by 1.5 percent. 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 percent. Thus, compared with the impact on the implied supply ratio of production/nonproduction 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 four-digit level carried out by Feenstra and Hanson (2000), we can evaluate the impact of U.S. trade on its factor markets. This shows that in the period of 1982–1994, changes in U.S. trade patterns had the effect of increasing the implied supply ratio of production/nonproduction workers available to the manufacturing sector for other use by 1.0 percent, while the implied supply of capital stock per worker available to the manufacturing sector for other use fell by 2.3 percent.[13] Thus, compared with the United States, 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/nonproduction 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 macroeconomy described in section 1.2, the offsetting effect of international trade seems to be small. Table 1.8 compares overall physical or human capital deepening in the Japanese manufacturing sector with that purely attributable to changes in factor contents of trade. Although the average annual growth rate of the capital-labor ratio for the manufacturing

13. In the period 1982–1994, the United States saw an increase in its factor content net imports of production (nonproduction) workers in manufacturing of 8.2 percent (7.2 percent). It also experienced a rise in factor content net imports of capital stock in manufacturing of 5.5 percent and a decline in net exports of (production plus nonproduction) workers of 7.8 percent of total workers in manufacturing.

Table 1.8 **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[a]	7.60[b]
Changes in factor contents of trade	n.a.	–0.06	0.41[a]	0.18[b]
Growth rate of the share of nonproduction 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

Source: Authors' calculation based on the results of tables 1.2, 1.3, and 1.7.

Note: n.a. = not available.

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

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

sector total is 7.60 percent for the 1980–1998 period, the growth rate becomes very small at 0.18 percent when we only take account of the change in the factor contents of trade. As for the growth rate of the share of nonproduction 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 nonproduction workers in the Japanese manufacturing sector is much larger, which implies a significant effect of international trade on Japan's human capital deepening.

1.4 Japan's Intraindustry Trade and the 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 nonproduction 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 nonskill-intensive activities abroad, then trade will lead to a shift in 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,b, 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, there are few studies analyzing the impact of fragmentation on labor and capital.[14]

Moreover, vertical intraindustry trade (VIIT), i.e., intraindustry 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 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 to 2000.[15] We also discuss the relationship between changes in factor demand and trade patterns by industry. Using industry-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 due to data constraints, the following analysis is limited to the manufacturing sector.

1.4.1 Industry-Level Overview of Fragmentation and Factor Intensity

Figure 1.6 shows the share of VIIT, a broad outsourcing measure, and a narrow outsourcing measure by industry for the year 2000, while figure 1.7 presents the average annual growth rates of these values from 1988 to 2000 by industry.[16] Following major preceding studies such as Greenaway, Hine, and Milner (1995) and Fontagné, Freudenberg, and Péridy (1997), our VIIT measure is 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 rela-

14. An exception is Sakurai (2000), who conducts a similar analysis for Japan. See section 1.4.2 for details.

15. As for the capital-labor ratio, due to data constraints, our analysis focuses only on the period from 1988 to 1998.

16. For the definition of VIIT and broad and narrow outsourcing measures, see appendix. For a more detailed analysis of VIIT in Japan and East Asia, see Fukao, Ishido, and Ito (2003).

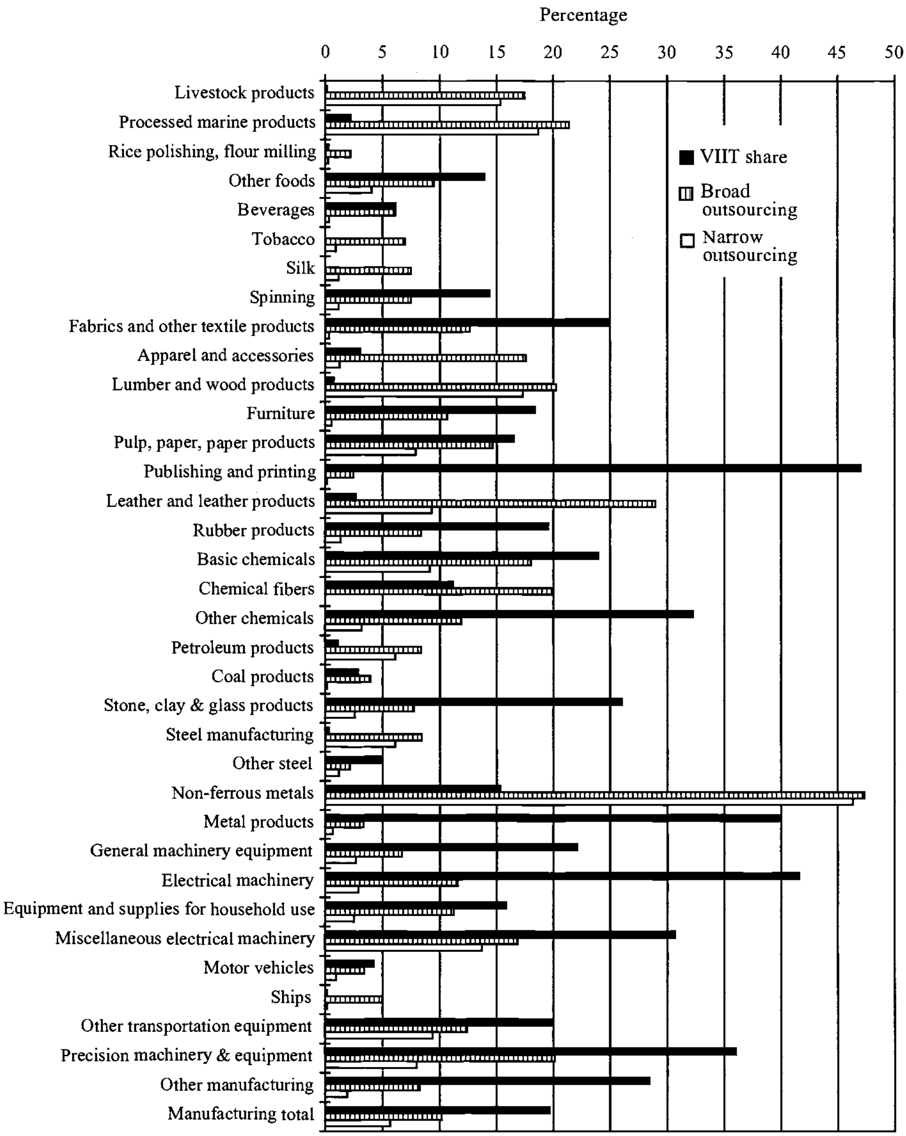
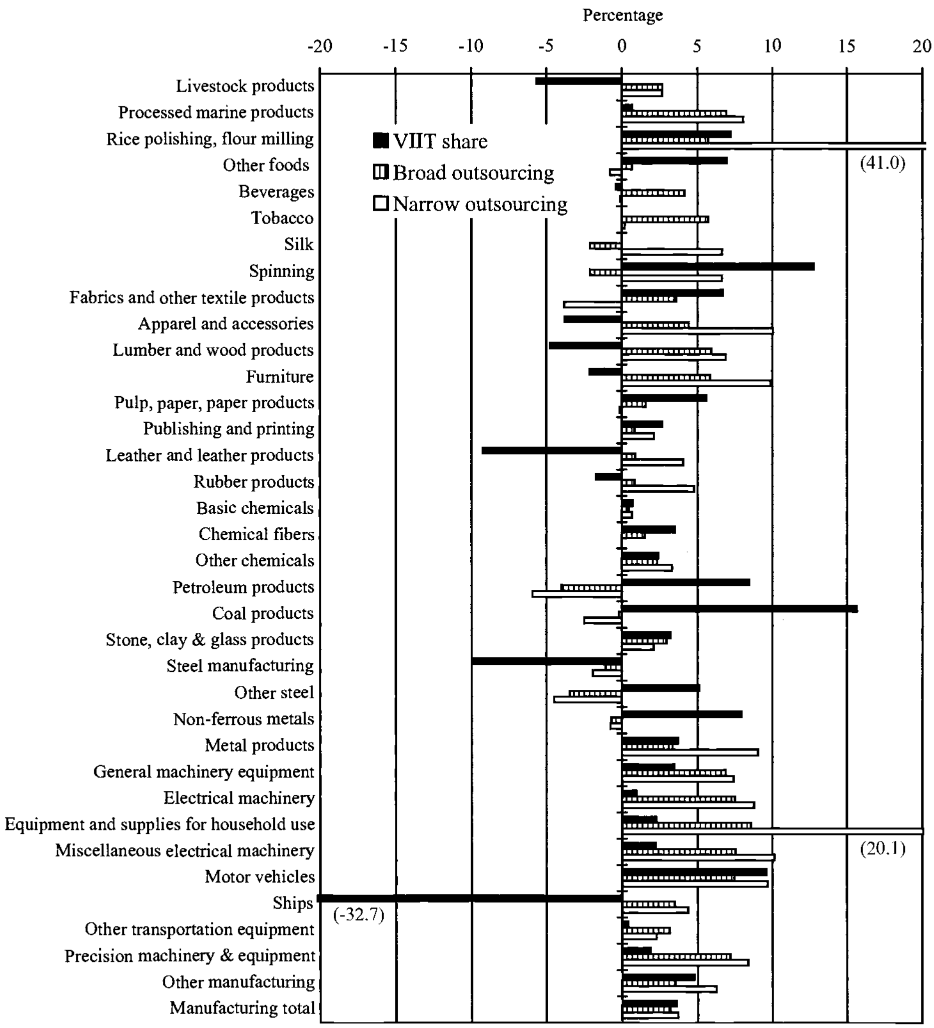


Fig. 1.6 Vertical intraindustry trade share and outsourcing share by industry: 2000
Source: Authors' calculation.

tive to total expenditure on nonenergy intermediate inputs in each industry. The narrow outsourcing measure expresses the imported intermediate inputs purchased from the same Japan Industry Productivity Database (JIP) industry as the good being produced divided by the total expenditure on nonenergy intermediate inputs in each industry. Figure 1.6 shows that



Growth rate of VIIT share: Δ ln (VIIT/Total trade)
Growth rate of broad outsourcing share: Δ ln (Broad outsourcing/Total intermediate inputs)
Growth rate of narrow outsourcing share: Δ ln (Narrow outsourcing/Total intermediate inputs)

Fig. 1.7 Annual growth rate of vertical intraindustry trade share and outsourcing share by industry: 1988–2000

the VIIT share in the year 2000 was relatively high (more than 30 percent) in publishing and printing, other chemicals, metal products, electrical machinery, miscellaneous 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, nonferrous 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, nonferrous metals, other electrical machinery, other transportation equipment, and precision machinery and equipment. Figure 1.7 shows that the VIIT share and outsourcing measures increased in most manufacturing sectors during the period from 1988 to 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, nonferrous metals, and motor vehicles.

Next, let us look at the correlations between changes in factor intensities, the VIIT share, and the outsourcing measures. Table 1.9 summarizes the correlation coefficients between the annual growth rates of the shares of skilled workers, nonproduction workers, the VIIT share, and the broad and narrow outsourcing measures for the period from 1988 to 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 nonproduction 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 con-

Table 1.9 **Correlation coefficient matrix**

	Capital-labor ratio (a)	Skilled worker share (b)	Nonproduction worker share (c)	VIIT share (d)	Broad outsourcing (e)	Narrow outsourcing (f)
(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

Source: Authors' calculation.

Note: Each variable denotes the average annual growth rate for the period from 1988 to 2000.

***Significant at the 1 percent level.

*Significant at the 10 percent level.

jecture that outsourcing or VIIT may have contributed to physical and human capital deepening in each industry.

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 to 2000. Several previous studies have analyzed the impact of fragmentation on skill upgrading (human capital deepening). Using detailed industry-level data for the United States, Feenstra and Hanson (1996a,b, 1999) estimate the effect of international outsourcing on wage inequality. Hijzen, Görg, and Hine (2003) conduct a similar analysis using U.K. data for fifty-three manufacturing industries for the period from 1982 to 1997. As for Japan, Sakurai (2000) analyzes this issue using data for thirty-nine manufacturing industries for the period from 1987 to 1990. While the studies on the United States and the United Kingdom 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 (thirty-five manufacturing industries) for the period from 1988 to 2000. In addition, we take account of the role of skill-biased technological change (SBTC) in the increase in skilled (nonproduction) worker intensity, utilizing the JIP IT (information technology) database.[17] As Hijzen, Görg, and Hine (2003) point out, the inclusion of the 1990s in the analysis is likely to be crucial as international fragmentation and information technology progressed rapidly during the decade. However, one drawback of our analysis is that we cannot calculate wage bills for skilled (nonproduction) and unskilled (production) workers due to data constraints. Therefore, we assume that the relative wage rates of skilled (nonproduction) and unskilled (production) workers have not changed over time, and we use the ratio of the number of skilled (nonproduction) workers to the total number of workers as a proxy for the share of skilled (nonproduction) 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

17. According to the argument put forward by Feenstra and Hanson (1999), both SBTC 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.

approach here. Similarly, following previous studies, we consider capital as a fixed input in the short run, while skilled and unskilled (nonproduction and production) workers are variable factors of production. Therefore, the short-run translog cost function can be presented as:

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

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

$$\text{(2)} \quad S_{ij} = \alpha_j + \sum_{s=1}^{J} \gamma_{js} \ln w_{ij} + \sum_{k=1}^{K} \varphi_{jk} \ln x_{ik}$$

Assuming that quality-adjusted wages will be identical across industries, the wage terms can be dropped from the right-hand side of equation (2). We consider technological change, VIIT, and outsourcing as structural variables and assume there are three kinds of capital, namely IT hardware, IT software, and non-IT capital. A full set of year dummies is included in order to capture economywide skill upgrading as well as year-to-year changes in the wage levels faced by all industries. Therefore, we estimate the following equation:

$$\text{(3)} \quad S_{ijt} = \varphi_{j0} + \varphi_{j1} \ln\left(\frac{\text{IThard}}{\text{VA}}\right)_{it} + \varphi_{j2} \ln\left(\frac{\text{ITsoft}}{\text{VA}}\right)_{it} + \varphi_{j3} + \ln\left(\frac{\text{NonIT}}{\text{VA}}\right)_{it} + \varphi_{j4} + \ln\text{VA}_{it} + \varphi_{j5}\left(\frac{\text{RDexp}}{\text{VA}}\right)_{it} + \varphi_{j6}\text{VIIT}_{it} + \varphi_{j7}\text{Outsourcing}_{it} + \varphi_{j8}\text{D}_t$$

where IThard, ITsoft, and NonIT denote the IT hardware stock, IT software stock, and non-IT capital stock, respectively; VA is the 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 shipments, Outsourcing reflects either broad or narrow outsourcing, and D is a full set of year dummies. Subscript t represents time. In order to examine potential differences in the effects of VIIT with Asian countries and with other countries on factor demands in Japan, we prepare three variables representing VIIT: first, Japan's VIIT with all countries in the world divided by the industry's shipments; second, Japan's VIIT with the nine Asian economies divided by the industry's shipments; and third, Japan's VIIT with all the countries except for the nine Asian economies divided by the industry's shipments.[18]

In addition, using the industry-level data, we examine whether the international division of labor contributed to physical capital deepening in Japan. We use the capital-labor ratio (physical capital stock divided by the 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 generalized least squares (GLS) estimation are presented in table 1.10. This shows that the estimated coefficients on ln(ITIhard/VA), ln(VA), and RDexp/VA are significantly positive in all cases where skilled workers' share (SKILLED) or nonproduction workers' share (NONPROD) in the total number of workers is used as the dependent variable (columns [1] to [4]). The results imply that (a) IT hardware intensity has a positive impact on skill upgrading, and SBTC may have increased the share of skilled (nonproduction) workers; (b) the scale effect is positive and greater value added is associated with a higher skilled (nonproduction) workers' share; and (c) 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 cases but one in 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/shipments has a much larger coefficient than VIITnon-asia9/shipments. This may reflect the fact that vertical foreign direct investment (FDI) in the Asian economies tends to consist of the transfer of low-skilled 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 economies. When the skill intensity is calculated as the share of nonproduction 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 nonproduction

18. For more details on the definition of the variables and data sources, see appendix.

Table 1.10 **GLS estimation results**

	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/shipments	0.1521***		0.0351		0.2435*
	(3.68)		(0.84)		(1.73)
VIITasia9/shipments		0.2241***		0.0370	
		(3.10)		(0.24)	
VIITnon-asia9/shipments		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

Source: Authors' calculations.

Notes: The presence of AR(1) autocorrelation within panels and heteroskedasticity across panels is assumed. The numbers in parentheses are *z*-statistics. All equations include year dummies which are suppressed here. The estimation period for equations (1) to (4) is 1988–2000, while the estimation period for equation (5) is 1988–1998. Dependent variables: SKILLED indicates skilled workers' share in total number of workers; NONPROD indicates nonproduction workers' share in total number of workers; KL indicates capital-labor ratio.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

and nonprofessional 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 the 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 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/shipments has a significantly positive coefficient, the small value of the Wald statistic 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.

1.5 Conclusion

Our aim in this paper was to investigate changing trade patterns and their effect on factor intensities in Japan, mainly focusing on the manufacturing sector. We had expected that the increasing division of labor between Japan and its East Asian neighbors during the last two decades would have affected factor prices in Japan and consequently offset the diminishing rate of return to physical and human capital. However, our results suggest that the far-reaching change in trade patterns has not substantially altered the long-term trend of diminishing rates of return to capital.

Starting from the observation that the capital-labor ratio and the share of skilled workers in the total number of workers have been growing over the last couple of decades, we first conducted decomposition analyses and found that most of the macroeconomic 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 interindustry trade that affects the size of each industry. However, the large within-industry effect led us to suspect that the division of labor and intraindustry trade between Japan and Asian countries may have contributed to the within-industry increase in capital intensity and skilled labor intensity. Therefore, in addition to examining the factor contents of trade from the aspect of interindustry trade, we also analyzed whether the deepening of the international division of labor and vertical intraindustry trade contributed to the within-industry change in factor intensities in Japan.

The factor content analysis showed that Japan's factor content net exports of capital and nonproduction labor have grown rapidly, while net exports of production workers have fallen by a large amount. Interestingly, the analysis also showed that the decline in the production worker content of net exports 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 nonproduction workers in the Japanese manufacturing sector as a whole, hardly any of the macro-level accumulation of physical capital was offset by the growth in factor content net exports of physical capital.

Moreover, 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 nonproduction workers. We should note that the skilled (professional, technical, managerial, and administrative) labor share in the total number of workers is only around 10 percent and is much lower than the share of nonproduction workers, which is around 30 percent.

According to our results, specialization in the export of skilled labor–intensive products may have partly 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, and so on. Davis and Weinstein (2003), who empirically tested the determinants of 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, however, is an issue that deserves closer scrutiny in future investigations.

Appendix

Definition of Variables Used in the Econometric Analysis and Data Sources

Labor Data

Data on skilled and unskilled labor were constructed mainly using the *Population Census of Japan,* published by the 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 (three-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 the Statistics Bureau, Ministry of Public Management, Home Affairs, Posts, and Telecommunications, because the results of the 2000 *Population Census* were not yet available. The *Employment Status Survey* is based on a series of surveys that cover approximately 1 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 nonproduction labor generally used in preceding studies. In the *Population Census* and the *Employment Status Survey,* workers are basically classified according to ten major groups as shown in table 1A.1. We distinguished two skill groups (skilled or unskilled) as well as production/nonproduction 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 nonproduction workers.

Table 1A.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

Notes: Skilled workers: groups 1 and 2. Production workers: group 9.

Measurement Method and Data Source for Vertical Intraindustry Trade

In order to identify vertical and horizontal intraindustry trade (IIT) we adopt the 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 traded between the two economies.

We break down the bilateral trade flows of each detailed commodity category into the following three patterns: (a) interindustry trade (one-way trade), (b) intraindustry 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:

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

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 intraindustry trade types, that is, one-way trade (OWT), horizontal intraindustry trade (HIIT), and vertical intraindustry trade (VIIT) as in table 1A.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.

We used Japan's customs data provided by the Ministry of Finance

Table 1A.2 **Categorization of trade types**

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

(MOF). Japan's customs data are recorded at the nine-digit HS88 level and the data classified by HS88 are available from the year 1988. The nine-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 a free on board (f.o.b.) basis, while import data are on a cost plus insurance and freight (c.i.f.) basis. We should note that our estimate of the VIIT share is biased upward because of this difference.

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

$$\text{(A1)} \qquad \sum_j \text{(input purchases of good } j \text{ by industry } i) \cdot \left[\frac{\text{(imports of good } j)}{\text{(consumption of good } j)} \right]$$

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 expenditures on nonenergy 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 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 table 1A.3. The correspondence between the JIP classification and the Fukao-Ito classification for manufacturing industries is presented in table 1A.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 (A1) to be within the same JIP industry. We should note that we only took account of intermediate inputs from manufacturing industries.

Table 1A.3 Correspondence table: Fukao-Ito classification correspondence to 1980-85-90 Japan linked I-O standard classification (manufacturing)

Fukao-Ito Classification	Linked I-O	Fukao-Ito Classification	Linked I-O
57 Beef meat (bone meat), pork (born meat)	1111-010	98 Manufactured ice	1129-031
58 By-products of slaughtering and meat processing	1111-015	99 Feeds	1131-011
59 Processed meat products	1112-011	100 Organic fertilizers, n.e.c.	1131-021
60 Bottled or canned meat products	1112-021	101 Tobacco	1141-011
61 Animal oils and fats	1112-031	102 Raw silk	1511-011
62 Drinking milk	1112-041	103 Fiber yarns	1511-021
63 Dairy products	1112-042		1511-031
64 Frozen fish and shellfish	1113-011		1511-041
65 Salted, dried, or smoked seafood	1113-021		1511-099
66 Bottled or canned seafood	1113-031	104 Cotton and staple fiber fabrics	1512-011
67 Fish paste	1113-041	105 Silk and artificial silk fabrics	1512-021
68 Fish oil and meal	1113-051	106 Woolen fabrics, hemp fabrics, and other fabrics	1512-031
69 Other processed seafoods	1113-099		1512-091
70 Milled rice	1114-011		1512-099
71 Other grain milling	1114-019	107 Knitting fabrics	1513-011
72 Wheat flour	1114-021	108 Yarn and fabric dyeing and finishing (processing)	1514-011
73 Other grain milled products	1114-029	109 Rope and nets	1519-011
74 Noodles	1115-011	110 Fabricated textiles for medical use	1519-031
75 Bread	1115-021	111 Other fabricated textile products	1519-099
76 Confectionary	1115-022	112 Woven fabric apparel, knitted apparel	1521-011
77 Bottled or canned vegetables and fruits	1116-011	113 Other wearing apparel and clothing accessories	1522-011
78 Preserved agricultural foodstuffs	1116-021	114 Carpets and floor mats, bedding, other ready	1529-090
79 Refined sugar	1117-011	115 Timber	1611-011
80 Other sugar and by-products of sugar	1117-019	116 Plywood	1611-021
81 Starch	1117-021	117 Wooden chips	1611-031
82 Dextrose, syrup, and isomerized sugar	1117-031	118 Wooden products for construction	1619-091
83 Vegetable oils, cooking oil	1117-040	119 Other wooden products, n.e.c.	1619-099
84 Vegetable meal	1117-043	120 Wooden furniture and fixtures, wooden fixtures	1711-010
85 Crude salt	1117-051	121 Metallic furniture and fixtures	1711-031
86 Salt	1117-052	122 Pulp, waste paper	1811-011
87 Condiments and seasonings	1117-061	123 Foreign paper and Japanese paper	1812-011
88 Prepared frozen foods	1119-011	124 Paperboard	1813-011
89 Retort foods	1119-021	125 Corrugated cardboard	1813-021
90 Dishes, sushi, lunchboxes, school lunch	1119-090	126 Coated paper and building (construction) paper	1813-022
91 Refined sake	1121-011	127 Corrugated cardboard boxes, other paper	1821-010
92 Beer	1121-021		
93 Ethyl alcohol for liquor manufacturing	1121-031	128 Other pulp, paper, and processed paper products	1829-090
94 Whiskey and brandy	1121-041	129 Newspapers	1911-011
95 Other liquors	1121-099	130 Printing, plate making, and book binding	
96 Tea and roasted coffee	1129-011		1911-021
97 Soft drinks	1129-021	131 Publishing	1911-031

(*continued*)

Table 1A.3 (continued)

Fukao-Ito Classification		Linked I-O
132	Ammonia	2011-011
133	Chemical fertilizer	2011-021 2011-029
134	Soda ash	2021-011
135	Caustic soda	2021-012
136	Liquid chlorine	2021-013
137	Other industrial soda chemicals	2021-019
138	Titanium oxide	2029-021
139	Carbon black	2029-022
140	Other inorganic pigments	2029-029
141	Compressed gas and liquified gas	2029-031
142	Other industrial inorganic chemicals	2029-099 2029-011
143	Ethylene	2031-011
144	Propylene	2031-012
145	Other petrochemical basic products	2031-019
146	Pure benzene	2031-021
147	Pure toluene	2031-022
148	Xylene	2031-023
149	Other petrochemical aromatic products	2031-029
150	Acetic acid	2032-011
151	Acetic acid vinyl monomer	2032-012
152	Styrene monomer	2032-013
153	Synthetic rubber	2032-014
154	Synthetic alcohol, ethylene dichloride	2032-019
155	Methane derivatives	2039-021
156	Oil and fat industrial chemicals	2039-031
157	Plasticizers	2039-041
158	Synthetic dyes	2039-051
159	Other industrial organic chemicals	2039-099 2039-011
160	Thermosetting resins	2041-011
161	Thermoplastic resin, polyethylene (low density)	2041-091
162	High functionality resins	2041-092
163	Other resins	2041-099
164	Rayon, acetate	2051-011
165	Synthetic fibers	2051-021
166	Medicaments	2061-011
167	Soap and synthetic detergents, surface active	2071-010
168	Cosmetics, toilet preparations, and dentrifrices	2071-021
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 products	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	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 glass	2511-010
195	Glass processing materials, other glass products	2519-090
196	Cement	2521-011
197	Ready mixed concrete	2522-011
198	Cement products	2523-011
199	Pottery, china, and earthenware for construction	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 products	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	2621-010
212	Hot rolled steel (special steel)	2621-016

Table 1A.3 (continued)

Fukao-Ito Classification	Linked I-O
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 nonferrous metals	2711-099
227 Nonferrous 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 Nonferrous metal castings and forgings	2722-031
232 Nuclear fuels	2722-041
233 Other nonferrous 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 apparatus	3013-011
240 Pumps and compressors	3019-011
241 Other general industrial machinery and equipment	3019-090
242 Mining, civil engineering, and construction materials	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 plywood	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	3029-099
255 Machinists' precision tools, metal molds	3019-021 3031-090
256 Copy machine, electronic calculator, word	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	3211-010
261 Radio and television sets	3211-021
262 Household electric appliance	3211-099
263 Electric computing equipment (main parts)	3311-010
264 Wired communication equipment, radio	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, transformers	3411-020
272 Electric lighting fixtures and apparatus	3421-011
273 Electric bulbs	3421-031
274 Batteries, wiring devices and supplies	3421-090
275 Passenger motor cars	3511-011
276 Trucks, buses and other cars, motor vehicles	3511-019
277 Two-wheel motor vehicles	3531-011
278 Internal combustion engines for motor vehicles	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

(*continued*)

Table 1A.3 (continued)

Fukao-Ito Classification	Linked I-O	Fukao-Ito Classification	Linked I-O
285 Aircraft	3622-011	295 Medial instruments	3719-031
286 Repair of aircraft	3622-101	296 Toys, sporting, and athletic goods	3911-010
287 Bicycles	3629-011	297 Musical instruments, audio and video recorders	3919-010
288 Transport equipment for industrial use	3629-091	298 Writing instruments and stationery	3919-031
289 Other transport equipment, n.e.c.	3629-099	299 Small personal adornments	3919-041
290 Camera	3711-011	300 "Tatami" (straw matting) and straw products	3919-051
291 Other photographic and optical instruments	3711-099	301 Ordnance	3919-061
292 Watches and clocks	3712-011	302 Miscellaneous manufacturing products	3919-099
293 Professional and scientific instruments	3719-011		
294 Analytical instruments, testing machine	3719-021		

Note: n.e.c. = not elsewhere classified.

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 (2004). 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 the JCER IT data.[19]

IT Software (Million Yen, 1990 Prices)

We constructed industry-level software stock data using the JIP database, the JCER IT data, and the software investment data underlying Motohashi (2002) and Jorgenson and Motohashi (2003).[20] The JCER data provide real software stock by two-digit industry but include only order-made software. In the JIP database, real software stock data that 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 two-digit industry using the

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

20. We are also grateful to Dr. Kazuyuki Motohashi at the University of Tokyo for providing the data.

Table 1A.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, and 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 Nonferrous 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 Miscellaneous 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 and equipment	290	291	292	293	294	295				
45 Other manufacturing	186	296	297	298	299	300	301	302		

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. Because 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 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 Manufacturers.* 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 intraindustry trade in total trade values. For our definition of vertical intraindustry trade and data sources, see the second section of the appendix.

VIITworld/shipments (%)

This variable is calculated as (VIIT · [exports + imports]/2/domestic shipments). 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/shipments (%)

This variable is calculated in the same way as VIITworld/shipments. 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-asia9/shipments (%)

This variable is calculated in the same way as VIITworld/shipments. 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 the 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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Comment Chin Hee Hahn

Here is what I think this paper did. First, this paper starts out with some facts. It shows that, compared with the United States, Japan's economic growth until the 1990s was more dependent upon inputs accumulation, such as physical capital and labor quality growth. Also, it shows that the rate of return on capital has declined continuously for the past three decades and that, compared with the United States, the college wage premium increased only slightly.

Then, this paper raises the following question. Does the changing trade pattern reflect the changes in factor endowment conditions in such a way as to prevent the forces of diminishing returns to set in? This question is motivated by the presumption that if the Japanese economy adequately specialized in the physical and human capital–intensive products, especially during the 1990s when international division of labor with other East Asian countries expanded, the rate of return to physical capital, in particular, might not have declined continuously as observed.

To address this question empirically, this paper examines both interindustry and intraindustry trade and relates them to the changes in factor intensities. First, this paper performs factor content analysis and finds out that during the 1990s Japan increased net exports of physical capital stock and nonproduction labor but decreased net exports of production labor, which is consistent with the Heckscher-Ohlin theory. That is, the authors find that in terms of interindustry trade, the changes in the trade pattern during the 1990s reflects deepening of physical and human capital. Then the authors move on to examine whether international division of labor with other East Asian countries or vertical intraindustry trade (VIIT) can explain capital deepening and skill upgrading. They do not find any significant relationship between VIIT and the capital-labor ratio. As for

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the skill upgrading, they get mixed results, which is sensitive to the definition of skilled labor.

The conclusion of the paper is that Japan is not adequately specializing in the export of capital-intensive goods so that trade did not play a large role in offsetting excess supply of capital.

Let me make several comments on this paper. My first comment is on the way the conclusion is drawn out. In fact, this paper carries out two types of analyses: factor content analysis and factor intensity regressions. However, with regard to the question of whether the changes in trade pattern adequately reflect the changes in factor endowments, these two analyses produces different answers. The factor content analysis shows that the changes in the trade pattern are consistent with capital deepening, for example. To the contrary, the factor intensity regressions show that the industry capital-labor ratio is not explained by VIIT. Because these two analyses give us two different pictures on the role of trade, the issue becomes a quantitative one. In other words, the issue becomes whether the factor content increase in the net export of capital during the 1990s was or was not sufficient enough to fully accommodate the aggregate capital deepening. However, the authors avoid this issue by providing a decomposition analysis, which suggests that aggregate capital deepening is largely attributable to within-industry effect. Based on this result, the authors seem to take the results on VIIT more seriously than the results by factor content analysis to reach their conclusion. Insofar as the decomposition analysis is sensitive to the level of aggregation, it doesn't seem to be clear enough whether we can draw out a clear conclusion relying on the capital-labor ratio regressions. That is, how much weight to put on the results from factor content analysis to evaluate the role of trade seems to be an unresolved issue. Recognizing this, the conclusion of the paper is only suggestive rather than conclusive.

My second comment is that the authors seem to rely too heavily on trade in order to explain the decline in rate of return to capital. Although the decline in the returns to capital could well be attributable to the inadequate changes in capital-intensive exports, it could be also attributable to the decline in the rate of total factor productivity improvement, especially during the 1990s. Table 1.1 of this paper clearly shows that the decline in the total factor productivity (TFP) growth rate is exactly what happened during the 1990s. Given this possibility, an entirely different interpretation of the results is not impossible. The story could go as follows. The factor content analysis suggests that the trade pattern changed, reflecting rapid capital deepening and skill upgrading. Although the decomposition exercise shows that capital deepening is largely attributable to within effect, this result could suffer from the industry aggregation problem and uncontrolled macroeconomic conditions. Thus, even though the VIIT did not contribute significantly to the capital deepening and skill upgrading, changes in trade patterns by and large played the role of offsetting the excess supply of capital. Given the decline in the TFP growth rate during the 1990s, the rate of return to capital would have declined further if it were not for the changes in trade patterns.

Comment Ji Chou

The paper utilizes Japanese economic data to analyze vertical intraindustry trade (VIIT) and the division of labor in East Asia comprehensively and rigorously. The paper covers aspects from macroeconomics, industrial level to firm level, and the paper analyzes the argument step by step and includes notes for the possible drawback of compiled data.

The paper achieves the research goal with some interesting issues left. First, the finding that VIIT instead of outsourcing has a strong and positive relationship with skilled workers' share contrasts cases in the United States (Feenstra and Hanson 1996a,b, 1999) and the United Kingdom (Hijzen, Görg, and Hine 2003), but the finding is similar to another Japanese study (Sakurai 2000).

Because VIIT is goods differentiated by quality, while outsourcing is the import of intermediate inputs, high quality products could be critical components, rare materials, and highly value added final products. The industry, whose outsourcing measure is high in Japan as shown in table 1C.1 is not necessarily a technology-intensive industry. Therefore, the demand for skilled workers might not be high.

Second, the between effect is negative in the decomposition of capital-labor ratio growth as shown in figure 2.5 and figure 2.6 of the text. The authors accused it of the decline in private investment. But the decline of private investment might be caused by the decline of export demand rather than domestic demand. Because the between effect reflects the reallocation of capital among industries, the negative between effect might imply that the price in Japan cannot reflect market change promptly. This argument corresponds to the authors' last statement in their conclusion: "VIIT patterns might not be determined by the price of capital, but by other factors."

Third, the regression in the study seems to use the pooling estimation; the panel data approach may provide more information about the time and cross-section aspect.

Fourth, the authors use single-country data to analyze the VIIT and the division of labor in East Asia. Although the analysis catches most pictures of the Asian trade structure, the contribution of the NICs' foreign direct

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Table 1C.1 Vertical intraindustry trade and high narrow outsourcing in Japan

High vertical intraindustry trade	High narrow outsourcing
Publishing and printing	Livestock products
Other chemicals	Processed marine products
Metal products	Lumber and wood products
Electrical machinery	Pulp, paper, and paper products
Other electrical machinery	Leather and leather products
Precision machinery and equipment	Basic chemicals
	Petroleum products
	Steel manufacturing
	Nonferrous metals
	Other electrical machinery
	Other transportation equipment
	Precision machinery and equipment

investment (FDI) to Association of Southeast Asian Nations (ASEAN) and China could be overlooked.

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