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Trade Patterns in Japan's Machinery Sector

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TRADE PATTERNS IN JAPAN'S MACHINERY SECTOR[*]

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Abstract

This paper analyzes trade patterns in Japan's machinery sector using disaggregated data of export and import commodities. It is found that the vertical intra-industry trade—the two-way trade of products differentiated by quality—with Asian countries expanded in the 1990s. According to the results of the empirical study, this trade pattern is closely related to differences in the capital/labor ratio between Japan and its trading partners, and to Japan's foreign direct investments. It suggests that the development of Japan's trade in the machinery sector in the 1990s is explained by traditional trade theory, i.e., that trade patterns depend on the difference in factor endowment between trading partners. Japan's foreign direct investment, too, has played an important role.

Keywords: Vertical intra-industry trade; Foreign direct investment; Asia
JEL Classification Number: F14; F20

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1. INTRODUCTION

Japan's trade has recently continued to expand in terms of both exports and imports. According to the sum of Japan's export and import values since 1990 given in Figure 1(1), it has increased by an annual average of 3 percentage points. Furthermore, a ratio of the sum of Japan's export and import values to its GDP has also risen steadily; it reached 23.3 percent in 2004.[1]

We then look at Japan's exports and imports by regions in Figure 1(2) to explore the background of such an increase in trade. The Figure shows that an increase in Japan's trade with Asian countries, including China, is significant. Traditional trade theory, i.e., the "Hechcher-Ohlin" theory (*HO* theory, hereafter), is likely to explain such a significant increase in trade with Asia appropriately, considering the cheap and abundant labor available in the Asian region. Traditional trade theory assumes one-way trade of products with different factor intensities, such as "capital-intensive" and "labor intensive" products, due to the difference in factor endowment of capital and labor between trading partners. This type of trade is generally called "inter-industry" trade, since it occurs between different industries in trading partners, i.e., between the domestic machinery (capital-intensive) industry and foreign textile (labor-intensive) industry.

However, when we look at Japan's trade with East Asia by industry in Figure 1(3), one reason for the increase becomes clear: "intra-industry" trade—in which both exports and imports expand within the same machinery sector—rather than the "inter-industry" trade—in which Japan exports machinery products to its trading partner while it imports textile products from there—has recently increased. The "intra-industry" trade is generally a two-way trade of products differentiated by their attributes such as their functions or designs between trading partners. It is commonly explained by assuming either imperfect competition or economies of scale (Helpman and Krugman (1985), *HK* theory, hereafter).

The above-mentioned intra-industry trade has been observed, by its properties, mainly in trade across developed countries where there are few differences in factor endowments.[2] Nonetheless, intra-industry trade in Japan's machinery sector has expanded with the Asian countries, despite large differences in factor endowments between Japan and those countries. How should such a trade pattern be explained?

This paper investigates trade patterns in Japan's machinery sector with actual trade data in terms of trade theory. Let us make this paper's conclusion clear:

- According to an analysis of trade patterns in Japan's machinery sector using fully disaggregated data of export and import commodities, it becomes clear that the "vertical" intra-industry trade, i.e., the two-way trade of the products differentiated by qualities

[1] The ratio is on the real basis to eliminate the effects of exchange rates or oil prices.

[2] See Balassa (1966), for example.

(factor-intensities), has largely increased, while the “horizontal” intra-industry trade, i.e., the two-way trade of products differentiated by attribute, as the HK theory supposes, remains at a low level.

- The increase in vertical intra-industry trade is closely related to the difference in the capital/labor ratio between Japan and its trading partners, and to Japan’s foreign direct investment.

The machinery sector on which this paper focuses consists of “general machinery,” “electric machinery,” and “precision machinery.” Trade in this sector made up 40 percent of Japan’s total trade in 2002, and it has largely affected the development of Japan’s total trade in recent years.[3] Japan’s trading partners in this study consist of 16 countries, including the Asian countries.[4]

This paper is organized as follows. Section 2 shows some trade patterns in Japan’s machinery sector by applying fully disaggregated data of export and import commodities, compiled in Japan’s trade statistics. In the analysis, we will point out that the share of vertical intra-industry trade has increased in Japan’s machinery sector, while that of inter-industry trade has declined, and that this trend is prominent in trade with the Asian countries. Section 3 considers the background of the increase in vertical intra-industry trade in terms of trade theory. The mechanism is described in the framework of partial equilibrium model based on the traditional trade theory, and the effects of foreign direct investment on the trade pattern are also discussed. In Section 4, we perform an empirical study on the determinants of trade patterns in Japan’s machinery sector. Section 5 concludes.

2. DESCRIPTIVE ANALYSIS OF TRADE IN JAPAN’S MACHINERY SECTOR

This section clarifies trade patterns in Japan’s machinery sector by using the fully disaggregated data of export and import commodities compiled in the “Japan Exports & Imports—Country by Commodity” by the Japan Tariff Association.

Section 2.1 describes a concrete procedure to clarify trade patterns in Japan’s machinery sector, and also mention some notices regarding the procedure. Section 2.2 indicates a few notable features of Japan’s trade patterns obtained from Japan’s trade data.

[3] The sum of Japan’s total trade in 2002 was 94.3 trillion yen; that in machinery sector totaled 33.3 trillion yen (author’s calculation). This paper analyzes the trade commodities contained in the classification of 84, 85, 90, 91, and 94 at the 2-digit HS codes, which will be discussed later in this paper.

[4] Japan’s trading partners in this study are selected from the top-20 countries in Japan’s total trade in 2002. We have, however, excluded four countries, because of the lack of data availability. The 16 selected trading partners are: the nine East Asian countries including China, South Korea, Taiwan, Hong Kong, Singapore, Malaysia, Thailand, Indonesia, the Philippines, and the following seven countries: the United States, Canada, the United Kingdom, France, Germany, the Netherlands, and Belgium.

2.1 *Classification of Trade Pattern*

It is conventional to classify trade value into inter-industry and intra-industry trades on analyzing the trade pattern. Practically, the classification is based on the degree of matching values between exports and imports of bilateral trade[5]; if one commodity is exported and imported simultaneously between two countries—that is, two-way trade—this commodity is classified as intra-industry trade. If the commodity is either exported to or imported from the other country—i.e., one-way trade—it is classified as inter-industry trade.

In such a classification procedure, we are confronted with the following problem: to what extent of the disaggregated data of export and import commodities should we use in measuring the intra-industry trade? We now discuss this point with some concrete examples.

The trade statistics contain HS codes (Harmonized Commodity Description and Coding System) to present classification standards for each trade commodity; the larger the number of digits assigned to each code, the more minutely classified the commodity is. It is hard to discuss rigorously which digit of classification codes should be appropriate to use. However, let us discuss this point with examples. Consider "TV" and "video," both of which are included in the trade commodities in the machinery sector. If we classified them with 4-digit HS codes, all would be classified as code number "8528" in a lump. It's not certain, however, whether we can regard both "TV" and "video" as the same commodity. Furthermore, if we classified them with the most disaggregated digit codes, i.e., the 9-digit HS codes, it would be difficult to link the export and import commodities on the same code number, since there are many differences in the classifications of export and import commodities at the 9-digit HS codes.[6] In this respect, it intuitively seems adequate to classify them with the 6-digit HS codes—which yields the five commodities of "color TV (code number: 8528-12)," "black-and-white TV (8528-13)," "color video monitor (8528-21)," "black-and-white video monitor (8528-22)," and "video projector (8528-30),"—in terms of their product attributes. In

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[5] The frequently used index to measure an extent of intra-industry trade is the "Grubel-Lloyd" index, defined as follows. See Grubel and Lloyd (1975).

$$GLI_i^{jf} = 1 - \frac{\sum | E_i^{jf} - E_i^{fj} |}{\sum | E_i^{jf} + E_i^{fj} |} \qquad 0 \le GLI_i^{jf} \le 1$$

where E_i^{jf} denotes export value from country j to country f. GLI approaches 1(0) by definition as the ratio of intra-industry (inter-industry) trade increases.

[6] The numbers of 9-digit HS codes corresponding to "TV" and "video" (8528 at the 4-digit HS codes) include 11 export commodities, 8528.12-111, 8528.12-119, 8528.12-190, 8528.12-900, 8528.13-111, 8528.13-119, 8528.13-190, 8528.13-900, 8528.21-000, 8528.22-000, 8528.30-000, and six import commodities, 8528.12-010, 8528.12-090, 8528.13-000, 8528.21-000, 8528.22-000, 8528.30-000. There are just three common commodities between exports and imports: 8528.21-000, 8528.22-000, and 8528.30-000.

addition, we do not face the above problem of linking the export and import commodities classified with the 6-digit HS codes with which we would be confronted at the 9-digit HS codes classification. Because the same arguments can be deployed for commodities other than "TV" and "video," we have decided to classify each trade commodity according to the 6-digit HS codes here.[7]

We have just described the way to measure the value of intra-industry trade as the matching values of export and import commodities with same code number. However, this procedure cannot identify patterns of intra-industry trade; the intra-industry trade consists of the "vertical" intra-industry trade, dealing with products with different factor intensities, and the "horizontal" intra-industry trade, dealing with ones with similar factor intensities but different attributes.

Let us explain again these types of trade with the above examples. The "color TV" classified with 6-digit HS codes includes high-quality TVs, i.e., "thin-model TVs" such as liquid-crystal color TVs or PDP (Plasma Display Panel) TVs, to low-quality TVs, i.e., "CRT (cathode ray tube) TVs." When Japan exports "thin-model TVs" to China, while it imports "CRT TV set" from there, this two-way trade is classified as vertical intra-industry trade that deals with the products differentiated by their qualities (or factor intensities); in this case, the difference in factor endowment between the trading partners is likely to matter for the type of trade, as traditional trade theory suggests.[8] Moreover, if the TVs have the same qualities but different attributes, such as their brands or designs, they are two-way trades and thus classified as horizontal intra-industry trade. In this case, imperfect competition or economies of scale should be important factors, as the HK theory suggests. In this way, intra-industry trade consists of two trade patterns: vertical and horizontal intra-industry trades, both of which have different determinants. It is therefore desirable to classify in advance intra-industry trade into these two types of trades on analyzing trade patterns more properly.

The preceding studies have used the unit-value of each commodity to classify the pattern of intra-industry trade. Here we assume that unit-values of export and import commodities reflect their intensities of factor inputs; when the gap between export and import unit-value on the same commodity is large, this commodity is classified as vertical intra-industry trade, consisting of different factor-intensive products. In contrast, when the gap is small, it is classified as horizontal intra-industry trade, consisting of products with similar factor-intensities but with different attributes. This classification of trade patterns has been actively performed in many preceding U.S. and European studies; even

[7] The commodity classifications on the current standard of HS codes are available only after 1988. Since a small revision of HS codes classification was done in 1996, the discontinuities in some codes are observed before and after the year. However, because we have aggregated the individual commodities by each trade pattern, the effects of such discontinuities do not seem serious on analyzing trade pattern over the periods.

[8] Details of the theory will be presented in Section 3.

in Japan, Fukao *et al.*(2003) have also analyzed trade patterns in Japan's electric machinery sector in detail.[9]

The concrete procedure to classify trade patterns in this paper is as follows[10]:

A) Values and quantities of export and import commodities classified at the 9-digit HS codes in Japan's machinery sector, compiled in the "Japan Exports & Imports—Country by Commodity," are re-classified at the 6-digit HS codes by trade partner countries.

B) Each commodity classified at the 6-digit HS codes classification is divided into inter-industry (one-way) and intra-industry (two-way) trades; a 10-percent threshold is applied to judge the matching values of export and import commodities as follows:

$$\frac{Min\,(X_i, M_i)}{Max\,(X_i, M_i)} \le 0.1 \quad \text{: Inter-industry trade}$$

$$\frac{Min\,(X_i, M_i)}{Max\,(X_i, M_i)} > 0.1 \quad \text{: Intra-industry trade}$$

where both X_i and M_i represent values of export and import commodities i classified at the 6-digit HS codes, respectively.

C) We calculate the unit-values of export and import commodities i of intra-industry trade, which are classified at the 6-digit HS codes in B), i.e., EP_i and IP_i, respectively; the unit-value is obtained by dividing the commodity value by its quantity. We basically use the number of pieces as a quantity index, but we also use weight for the commodities whose number of pieces are not available[11];

D) Intra-industry trade is classified as vertical and horizontal intra-industry trades on the basis of the gap between the unit-values of export and import commodities calculated in C); a 25-percent threshold value is applied to judge the gap between their unit-values.[12]

$$\frac{EP_i}{IP_i} < \frac{1}{1.25},\ \frac{EP_i}{IP_i} > 1.25 \quad \text{: Vertical intra-industry trade}$$

$$\frac{1}{1.25} \le \frac{EP_i}{IP_i} \le 1.25 \quad \text{: Horizontal intra-industry trade}$$

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[9] For the preceding literature analyzing trade patterns in Europe and the United States, see, e.g., Greenaway *et al.* (1995) for the U.K. trade (at the 5-digit code), Fontagné *et al.* (1997) for the EU regional trade (at the 8-digit code), and Durkin and Krygier (2000) for the U.S. trade (at the 5 digit-code). For the preceding study in Japan, Fukao *et al.* (2003) have analyzed Japan's trade at the 9-digit codes classification.

[10] The classification procedure here follows those performed in the forecited Fontagné *et al.* (1997) or Fukao *et al.* (2003).

[11] Whether to use weight or number of pieces as the quantity standard depends on the studies. The qualities of products in the machinery sector are in general considered irrelevant to their weights so that we have decided to use the number of pieces as the quantity standard.

[12] 15-percent threshold value is also applied, and the obtained results are almost as same as the ones calculated with a 25-percent threshold value (the results are abbreviated).

We perform the above procedure from A) to D) during the period 1988-2002 for Japan's bilateral trades with 16 trading partners. The main properties of Japan's trade patterns classified by the above procedure are described as follows:

Inter-industry trade: a *one-way* trade of different products on which domestic and foreign countries have comparative advantages, respectively.

Vertical intra-industry trade: a *two-way* trade of products differentiated by their qualities, i.e., their factor intensities.

Horizontal intra-industry trade: a *two-way* trade of products differentiated by their attributes, such as varieties, designs, or brands.

This approach gives us, to some extent, useful information on comprehending trade patterns. We must, however, pay attention to the following points.

First, the problem on classification standard of trade commodities to measure the intra-industry trade should be worth noting; although we have discussed the validity of classification strategy at the 6-digit HS codes with some concrete examples of "TV" and "video," this strategy is not necessarily absolute. Generally, if the classification standards of trade commodities are rough (minute), the number of commodities that match in terms of export and import values increases (decreases), and the values of intra-industry trade become overestimated (underestimated). Second, when trade imbalances occur for various reasons,[13] the intra-industry trade might be underestimated. Finally, the problems on the measurements of export and import unit-values should be pointed out. For example, both export and import unit-values are affected by factors—such as exchange rate, firm's price-setting behavior, and tariffs—other than by the difference in quality of each product. In addition, the values of export and import products are reported on different standards: export products are valued at an f.o.b. basis, whereas import products are valued at a c.i.f. basis.[14] Moreover, the rough classification of trade commodities results in an aggregation problem—i.e., the rough category of commodity includes various kinds of products—that contaminates the information on unit-values of the corresponding commodity.

Section 2.2 below takes up these problems, and shows some features of Japan's

[13] Plausible reasons might be the tendencies toward domestic products, and conventional or institutional factors such as tariff and non-tariff barriers. International differences in factor endowment and technology level and economies of scale are indicated on the supply side, while the strong and weak demand for intermediate inputs stemming from the difference in industrial structure and so forth are indicated on the demand side. See Kimura and Kohama (1995).

[14] In this respect, Fukao *et al.* (2003) have adjusted discrepancies between f.o.b. export prices and c.i.f. import prices under regular assumptions. We, however, have not done such adjustments.

trade patterns obtained by the above procedure.

2.2 *Features on Trade Patterns*

Figure 2 presents the classification results of Japan's trade in the machinery sector into some different trade patterns on the basis of the procedure described in 2.1. Some notable features on the trade pattern are worth mentioning:

- According to the value of Japan's trade in machinery sector in Figure 2(1), all trade patterns have increased in the 1990s; it is especially remarkable that vertical intra-industry trade has increased. According to the share of each trade pattern, which is the ratio of each trade pattern to Japan's total trade in the machinery sector,[15] the share of inter-industry trade has declined from 59.8 percent in 1990 to 47.0 percent in 2002, while that of vertical intra-industry trade has increased from 36.2 percent to 45.4 percent during the period. The share of horizontal intra-industry trade has remained at the low, single-digit level throughout the entire period (from 3.9 percent to 7.6 percent).

- The above features are observed more prominently in trade with Asia in Figure 2(2), in which the increase in vertical intra-industry trade is remarkable. According to the share of each trade pattern, while the share of inter-industry trade has declined from 67.9 percent to 46.8 percent, that of vertical intra-industry trade has significantly increased, from 25.6 percent to 45.7 percent. The share of horizontal intra-industry trade with Asia has remained low, i.e., from 6.5 percent to 7.4 percent; this feature is the same as horizontal intra-industry trade with all trading partners.

- Further, according to changes in trade patterns by country in Table 1, the shares of vertical intra-industry trade with the Asian countries, especially with China, Singapore, the Philippines, and Indonesia, have increased during the entire 1990s. The shares of vertical intra-industry trades with a part of other countries (developed countries) such as France, Germany, and Canada, have also increased, although their rates of increase are smaller than those in vertical intra-industry trades with the Asian countries.

In sum, the share of the horizontal intra-industry trade in Japan's machinery sector has remained extremely low since 1990, and that feature holds regardless of Japan's trading partners. Therefore, it is not enough to explain Japan's trade in the machinery sector solely by the HK theory. In contrast, vertical intra-industry trade has rapidly increased during the 1990s, and it is just as valid, for the trades with the Asian countries in particular.

From the following section, we consider the backgrounds of such trade patterns in both theoretical and empirical aspects.

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[15] For example, the share of inter-industry trade corresponds to the ratio of inter-industry trade value to total trade value, which is the sum of inter-industry, vertical intra-industry, and horizontal intra-industry trade values in the machinery sector.

3. DETERMINANTS ON TRADE PATTERNS: THEORETICAL FRAMEWORK

On the one hand, traditional trade theory posits that inter-industry trade occurs mainly due to the differences in factor endowments between trade-partner countries. On the other hand, horizontal intra-industry trade is explained by the presence of either economies of scale or imperfect competition, as the HK theory suggests.[16]

From the analyses in the previous section, it is clear that vertical intra-industry trade in Japan's machinery sector—which is different from both trade patterns mentioned above—has expanded significantly. This section describes the mechanism on how such a trade pattern occurs from a theoretical aspect. The following section shows the mechanism by a partial equilibrium model based on traditional trade theory. Section 3.2 considers the effects of increase in direct investment of home country to foreign on the trade patterns between them by performing a static comparative analysis in the above theoretical framework. Section 3.3 concludes and discusses a few points related to the empirical study in Section 4.

3.1 *Vertical Intra-Industry Trade Model*

We describe the mechanism of how two-way trade of the same products with different qualities, i.e., vertical intra-industry trade, occurs on the basis of the partial equilibrium model based on Falvey (1981).

Let us now describe the model. For simplicity, the model focuses on the trade within domestic and foreign machinery industries only, not on the total trade between different countries.[17] The machinery industry produces products with various qualities using capital and labor; the quality of the product is assumed to depend on the capital/labor ratio that went into the production. The capital assumed here is the production equipment in the factory, in which the manufacturing technology is embodied. Accordingly, we need to input more capital to produce a product with higher quality. Moreover, it is assumed that the capital is industry-specific and immobile across countries, but that is freely used within the industry.

Furthermore, while traditional trade theory assumes only two kinds of products, i.e., the "capital-intensive products" and the "labor-intensive products," we assume a continuum of products differentiated by their qualities; i.e., there are a number of

[16] According to the Chapter 8 in Helpman and Krugman (1985), it is shown that, in their monopolistic competition model, the horizontal intra-industry trade in equilibrium is related not to the differences in factor endowments between trading partners but to the difference in their country sizes under the assumption of two-countries, two-goods of homogenous and differentiated goods, and two-production factors of capital and labor.

[17] See Dornbusch *et al.* (1980) for a theoretical study in the framework of the HO trade model to analyze how vertical intra-industry trade takes place between two countries, not between domestic and foreign industries, on the assumption of the continuum of products differentiated by their qualities.

products with different qualities that are classified as the same commodity. The quality of a product is represented as the index q ($q \in [\underline{q}, \overline{q}]$), which corresponds to the ratio of capital to labor that went into the manufacturing of each product. When it approaches $\overline{q}$ ($\underline{q}$), it means that the capital-intensity of each product becomes high (low). More concretely, the product assumed here is considered as a commodity classified with 6-digit HS codes in the previous section, and many products with different qualities are contained in the commodity classification. For instance, the commodity classified as "TV" includes products with different qualities from "thin-model TVs" to "CRT TVs," and the qualities of these products are dependent on the relative amounts of capital to labor inputs that went into their productions.

The demand for products is assumed to depend on the relative prices of various products, which differ by their qualities, and consumer incomes. Such a loose assumption on the demand side follows that of traditional trade theory, which emphasizes the supply-side determination of trade patterns.

Assume that both domestic and foreign industries possess the given amounts of capital, i.e., K and K^*, respectively. This capital adjusts so as to work fully through the changes in their capital prices, i.e., r and r^*. When demand and supply for domestic and foreign capital are equal, the following relationships hold:

$$D^K(r, r^*) = K \quad (3\text{-}1)$$

$$D^{K^*}(r, r^*) = K^* \quad (3\text{-}2)$$

where $D^K(r, r^*)$ and $D^{K^*}(r, r^*)$ represent the demand for home and foreign capital, which depend on their capital prices; and D_i^K and $D_i^{K^*}$, i.e., the partial derivatives of D^K and D^{K^*} with respect to their prices i ($i = r, r^*$), satisfy the conditions of $D_r^K < 0$, $D_{r^*}^K > 0$, $D_{r^*}^{K^*} < 0$, and $D_r^{K^*} > 0$.

Here, we assume that the capital/labor ratio in the domestic industry is higher than the ratio in the foreign industry. It is also assumed that the domestic and foreign industries can employ workers at given prices (wages), and that the worker's wage in the domestic industry, w, is higher than that in foreign industry, w^*: i.e., $w > w^*$. In addition, the capital prices in the domestic industry, r, determined by (3-1) is assumed to be lower than that in foreign industry, r^*, determined by (3-2): i.e., $r < r^*$ holds.[18]

On the condition that the input-output ratios of home and foreign industries are identical, it is also assumed that one unit of labor and q units of capital are needed to manufacture one unit of product with quality q. In this case, the production costs of domestic and foreign industries, π and π^*, respectively, are given by

[18] Both wage and capital price represent the prices per unit.

$$\pi(q) = w + qr \tag{3-3}$$

$$\pi^*(q) = w^* + qr^* \tag{3-4}$$

When the domestic and foreign industries trade freely, there exists the quality level q^E ($q^E \in [\underline{q}, \overline{q}]$) from (3-3) and (3-4), which satisfies $\pi(q^E) = \pi^*(q^E)$:

$$q^E = \frac{w - w^*}{r^* - r} \tag{3-5}$$

In Figure 3, the vertical axis represents the costs of home and foreign industries that are necessary to produce one unit of the product with quality q, while the horizontal axis denotes the index of product quality q. The above equations (3-3) and (3-4) and their intersection point shown in (3-5) are shown in the Figure where the thick line represents the production cost curve with which both the domestic and foreign industries are confronted. According to the Figure, the cost advantage on the production between domestic and foreign industries is determined by whether the quality of the product is higher or lower than the quality q^E: that is, while the domestic industry has some cost advantage on manufacturing the product with quality higher than q^E ($q^E < q$), whereas the foreign industry accomplishes the same thing with quality lower than q^E ($q < q^E$). Consequently, domestic industry specializes in the production of high-quality products ($q^E < q < \overline{q}$) while foreign industry specializes in the production of low-quality products ($\underline{q} < q < q^E$). As a result, two-way trade in the same products with different qualities (factor-intensities)—i.e., the "vertical intra-industry trade"—occurs between the domestic and foreign industries.

3.2 *Effects of Foreign Direct Investment*

In general, direct investment toward a foreign country contributes to the accumulation of foreign capital.[19] This subsection considers the effects of an exogenous increase in the capital of foreign industry K^*—due to the increase in the home country's direct investment toward foreign industry at a certain point—on trade patterns.[20]

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[19] We dare to mention foreign direct investment here to advance an increase in foreign capital. In the next section we will discuss an empirical study on the relationship between Japan's foreign direct investment, which has recently intensified, and vertical intra-industry trade.

[20] See Mundell (1957) for the earliest literature on the relationship between international capital mobility and trade patterns. Mundell discussed in the framework of the classical two-sector HO model: when international capital flow occurs between trading partners, their factor prices become equalized, leading to a decrease in the volume of trade. The relationship between foreign direct investment and trade patterns has recently been studied from the point of view of the activities of multinational firms. In these studies, it is explained that the difference in factor endowment between trading partners, various costs of technology, trade, or foreign production, and market structure of trading partners are important factors for the activities of multinational firms or trade patterns. See, e.g., Markusen (2002).

More precisely, we consider by a comparative static approach how the threshold value of product quality q^E denoted by (3-5) changes when only the capital of foreign industry increases marginally, by one unit. According to (3-1) and (3-2), the increase in foreign capital affects the demand for both domestic and foreign capital through their price changes.[21] The effects are described by

$$D_r^K dr + D_{r^*}^K dr^* = 0 \qquad (3\text{-}6)$$

$$D_r^{K^*} dr + D_{r^*}^{K^*} dr^* = dK^* \qquad (3\text{-}7)$$

From (3-6) and (3-7), the effects of the marginal increase in K^* on the capital prices of domestic and foreign industries are shown as

$$dr = -\frac{D_{r^*}^K}{\Delta} dK^* < 0 \qquad (3\text{-}8)$$

$$dr^* = \frac{D_r^K}{\Delta} dK^* < 0 \qquad (3\text{-}9)$$

where Δ is

$$\Delta = D_{r^*}^{K^*} D_r^K - D_r^{K^*} D_{r^*}^K$$

It becomes positive under the assumption that the demand for capital in domestic and foreign industries decreases on the whole when the capital price in one country increases: i.e., $D_r^K + D_r^{K^*} < 0$, $D_{r^*}^K + D_{r^*}^{K^*} < 0$.

The above (3-8) and (3-9) show that the capital prices of home and foreign industries move in the same direction as a result of the increase in foreign capital. Therefore, the effects of the increase in foreign capital on q^E depends on the relative magnitude of the changes in capital of home and foreign industries, dr and dr^*, respectively. Taking the difference of (3-8) and (3-9) yields

$$dr^* - dr = \frac{(D_{r^*}^K + D_r^K)}{\Delta} dK^* \qquad (3\text{-}10)$$

Under the assumption that the demand for domestic capital decreases when the capital prices in both domestic and foreign industries increase by one unit together, the following

21 In this model, an increase in the capital stock of foreign industry does not lead to any changes in domestic and foreign wages, which are set as given by definition. Moreover, since industry-specific capital is assumed in the model, no adjustments occur between machinery and other sectors.

inequality holds:[22]

$$D^K_{r^*} + D^K_r < 0$$

Hence, the right side of (3-10) becomes negative. In such a case, the denominator of the right side of (3-5), $(r^* - r)$, declines and q^E increases so that the extent of product quality on which the foreign industry has cost advantages broadens.

The analysis in the previous section has shown that, in trade in Japan's machinery sector, the share of vertical intra-industry trade has increased, especially in trade with the Asian countries, whereas that of inter-industry trade has declined. We now sketch the mechanism of the change in the trade patterns in Figure 4 on the basis of the above discussion.

Assume the case in which a large gap exists in the capital/labor ratio between domestic and foreign industries before the direct investment toward the foreign industry occurs. Hence, the home industry is assumed to have a cost advantage on manufacturing almost all qualities of the products: the range of quality is $q^E_A < q < \overline{q}$ in Figure 4. In this case, the home industry manufactures and exports their products with any qualities, and consequently the share of one-way trade from home to foreign industry, i.e., an inter-industry trade, dominates a large share of the trade between domestic and foreign industries (e.g., Japan's trade with Asia *before the 1990s*).

When direct investment toward the foreign industry takes place and the capital of the foreign industry consequently increases marginally, the production cost functions of domestic and foreign industries shift from $\pi_A(q)$ to $\pi_B(q)$ and from $\pi^*_A(q)$ to $\pi^*_B(q)$, respectively, through the adjustments of capital prices in home and foreign industries according to (3-8) and (3-9). This results in a shift of the threshold of product quality from q^E_A to q^E_B, allowing the foreign industry to manufacture the products with the range of quality, $q^E_A < q < q^E_B$, in which the domestic industry used to have a cost advantage before the direct investment has occurred. As a result, the domestic industry specializes in manufacturing products with the range of quality, $q^E_B < q < \overline{q}$, while the foreign industry makes the products with the range of quality, $\underline{q} < q < q^E_B$. Therefore the two-way trade, i.e., the intra-industry trade, occurs between domestic and foreign industries, and the share of vertical intra-industry trade is likely to increase (e.g., Japan's trade with Asia *in the 1990s*).[23]

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[22] It can also be interpreted that the demand for home capital is a decreasing function of the relative price of domestic and foreign capital, r / r^*.

[23] However, in a narrow sense, the share of vertical intra-industry trade does not necessarily increase. Suppose that capital accumulation in foreign industry has been largely advanced by the direct investment, and production in home industry is completely transferred to foreign industry; in such a case, q^E_B in Figure 4 approaches unlimitedly to $\overline{q}$, and the capital costs may finally be equalized between home and foreign industries. The effect on trade pattern is only the reverse of exports and imports between home and

3.3 *Summary*

This section has described the mechanism of how the vertical intra-industry trade arises in the framework of traditional trade theory by assuming the continuum of products differentiated by their qualities. In this framework, the intra-industry trade of the products differentiated by their qualities takes place due to the difference in the capital/labor ratio between domestic and foreign industries. Moreover, it has also been discussed that the foreign direct investment affects the vertical intra-industry trade by accumulating the capital of foreign industry.[24]

There have been large gaps in the factor endowment between Japan and the Asian countries, and Japan's direct investment toward the region was galvanized in the 1990s. Behind such active advances of Japan's multinational firms toward Asia, we can indicate the constructions of their global production networks. For example, firms have long been outsourcing a part of many fragmented production stages to the Asian countries including China.

In this respect, the ratio of intermediate product to total intra-industry trade (intermediate product ratio, hereafter) in the trade with the Asian countries has increased from 42.8 percent in 1990 to 61.7 percent in 2002, as shown in Figure 5(1). Meanwhile, the ratio of trade with other countries shows a slight increase, from 40.1 percent to 48.3 percent. Moreover, we also measure the intermediate product ratios in both vertical and horizontal intra-industry trades by regions; the ratio in the vertical intra-industry trade has increased remarkably, especially in trade with the Asian countries, from 37.1 percent to 61.6 percent in Figure 5(2). Thus, the increase in Japan's vertical intra-industry trade with Asia has been coupled with the increase in intermediate product ratio, and is likely to have a close relationship with the development of international division of labor in production stages, including foreign outsourcing.[25]

The next section performs an empirical study on the determinants of trade patterns in Japan's manufacturing sector with the data of Japan and its trading partners.

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foreign industries, and the fact of one-way trade (inter-industry trade) to dominate a large portion to total trade does not change before and after foreign direct investment.

[24] The analysis here is based on the theory of static comparative advantage. In fact, considering that China and other East Asian countries have been promoting technological development, the future analysis may need to be based on the theory of dynamic comparative advantage, taking account of productivity changes in each country.

[25] Feenstra and Hanson (2003) have done an extensive survey on international division of labor in the global production system and on trade of intermediate products. Kleinert (2003) has reported that the recent increase in trade of intermediate products has been closely related to either global sourcing to procure foreign intermediate products at a low cost or outsourcing activity through foreign direct investment. His reporting is the result of empirical study based on the data of input-out table of OECD countries and German time-series data.

4. EMPIRICAL STUDY

This section presents the empirical study on the determinants of trade patterns in Japan's machinery sector on the basis of the theoretical consideration described in Section 3.

4.1 *Overview of the Preceding Literature*

Although a distinguished literature examining the determinants of Japan's trade volume exists,[26] studies on the determinants of its trade patterns—and in particular, on those of intra-industry trade—have been limited.

Among those preceding studies, Wakasugi (1997), one recent important study, has analyzed an increase in the share of intra-industry trade from the late 1980s to the first half of the 1990s in terms of the difference in factor endowment (i.e., the difference in GDP per capita) and in production technology between Japan and its trading partners. The result has indicated that the increase in the share of intra-industry trade has been brought about by either the increase in the technology transfers through foreign direct investment or through the enhancement of multinational networks.

In addition, Fukao *et al.* (2003) have classified the trade in Japan's electric machinery sector into inter-industry, vertical intra-industry, and horizontal intra-industry trades in the same way this paper has; they have attempted an empirical study on the determinants of the share of vertical intra-industry trade. They have reported that since the share of vertical intra-industry trade is positively related to the sales ratio of foreign affiliates in Japan's electric machinery sector, Japan's foreign direct investment has played an important role in the sharp increase in the vertical intra-industry trade.[27]

This paper analyzes the determinants on the share of vertical intra-industry trade as well as Fukao *et al.* (2003). We undertake the empirical study on the determinants in terms of the difference in the capital/labor ratio between trading partners and foreign direct investment along the lines of the discussion in Section 3. We also examine the relationship between the share of vertical intra-industry trade and foreign direct investment in terms of the trade with the Asian countries and the process division of labor within the machinery industry.

4.2 *Model Specification*

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[26] See, e.g., Lipsey and Ramstetter (2003), Kiyota (2003), and Koike (2004) for recent studies that have analyzed the determinants on Japan's trade volume based on the gravity model, especially in relation to foreign direct investment (or foreign affiliate activity).

[27] Fukao and Okubo (2004) have also discussed backgrounds of increase in vertical intra-industry trade in Japan's electric machinery sector, which was obtained in Fukao *et al.* (2003), in terms of the development of vertically integrated international division of labor between Japan and the East Asian countries.

The notable feature on recent trade in Japan's machinery sector is a rapid increase in the share of vertical intra-industry trade, especially in trade with the Asian countries. The previous sections have considered the hypothesis from a theoretical aspect that the difference in capital/labor ratio between trading partners and the foreign direct investment has played important roles in the increase.

We now attempt to examine the above hypothesis using the panel data by countries. Notice, however, that the focus here is to examine whether our hypothesis holds for Japan's bilateral trade, i.e., trade between Japan and its trading partners, not for the multilateral trade, i.e., trade between any trading partners. The baseline model is to linearly regress the shares of Japan's vertical intra-industry trade with its trading partners to the logarithms of the differences in real GDP per capita between Japan and its trading partners, and the logarithms of Japan's foreign direct investment toward them:

$$S_{jit}^{V} = \alpha + \beta_1 \ln\left|yc_{jt} - yc_{it}\right| + \beta_2 \ln f_{ji,t-1} + v_{jit} \qquad (4\text{-}1)$$

where the subscripts j, i, and t denote Japan, its trading partner, and year, respectively; S_{jit}^{V} represents the share of vertical intra-industry trade between Japan and its trading partner i to the total trade in Japan's machinery sector (logistic transformed value); yc_{it} is the real GDP per capita of country i; $f_{ji,t-1}$ is Japan's direct investment to the country i; α is a constant term; β_1 and β_2 are parameters; and v_{jit} is the error term.

The second term in the right side of (4-1) is supposed to be the variable of the difference in the capital/labor ratio in the machinery sector between Japan and its trading partner. However, it is hard to obtain such a variable by country, so we use as a practical estimate the variable of the difference in real GDP per capita between the countries as a proxy for the difference in the capital/labor ratio.[28] Moreover, foreign direct investment, i.e., the third term in the right side of (4-1), is considered to affect the trade after it accumulates as capital stock. The variable of foreign direct investment is thus included as the accumulated value of the foreign direct investment flow. In addition, one period-lagged variable is used to avoid the problem of simultaneity bias with the variable of trade.[29]

[28] For the difference in real GDP per capita between two countries to be an appropriate proxy for the difference in their capital/labor ratios, it is necessary to assume that their production factors consist of only capital and labor, and that all goods are freely traded across countries; see Helpman (1987). Meanwhile, Linder (1961) interpreted the difference in real GDP per capita between two countries to represent the demand properties, i.e., the differences in their consumer tastes.

[29] The choice whether multinational firms do trade or invest toward foreign countries should be made simultaneously, considering the relative cost on trade and investment. Therefore, it is supposed to use appropriate instrumental variables on estimating (4-1) to deal with this simultaneity problem between trade and investment. It is difficult, however, to find such adequate variables to satisfy the condition; see Head and Ries (2004). Therefore, we have decided to use a one-period lagged variable of foreign direct

The expected signs of parameters in (4-1) are $\beta_1 > 0$ and $\beta_2 > 0$. The former supports the hypothesis that the larger is the difference in the capital/labor ratio between trading partners, the higher is the share of vertical intra-industry trade between them. The latter supports the hypothesis that Japan's foreign direct investment raises the share of vertical intra-industry trade through the accumulation of capital in its trade-partner countries.

We also estimate the models in which the variable of foreign direct investment and various dummy variables are included in addition to the above baseline model; we estimate the model in which the cross-term consisting of foreign direct investment and the Asian-dummy or the intermediate product dummy is added to the right side of (4-1).

First, the cross-term consisting of foreign direct investment and the Asian-dummy variables is included in (4-1) to test the hypothesis that the foreign direct investment has played the role in increasing the share of vertical intra-industry trade, especially in trade with the Asian countries. The estimation model is

$$S_{jit}^{V} = \alpha + \beta_1 \ln\left|yc_{jt} - yc_{it}\right| + (\beta_2 + \beta_3 ad) \times \ln f_{ji,t-1} + v_{jit} \qquad (4\text{-}2)$$

where ad is an Asian-dummy variable, which takes 1 when Japan's trading partner i is an Asian country. Otherwise, it takes 0.

If the parameter β_3 on the cross-term of the fourth variable in the right side of (4-2) is estimated to be positive and statistically significant, it suggests that the positive relationship between the share of vertical intra-industry trade and foreign direct investment is strong, particularly in the trade between Japan and the Asian countries, which statistically supports the aforementioned hypothesis.

Next, the cross-term consisting of foreign direct investment and intermediate product dummy variable is included in (4-1). As the international division of labor by production processes within industry—i.e., the system to produce and trade between trading partners the intermediate products such as parts or materials of products based on different production stages within industry—develops, the ratio of intermediate products to total trade is expected to rise. As described in the previous section, the multinational firms have established the global production system, in which a whole production line is fragmented into different stages across appropriate countries. This phenomenon has recently been observed especially in the electric machinery sector, in which both parts and products are highly modularized. In such a world, the share of two-way trade of intermediate products, not of final products, between countries is supposed to rise, accompanying an increase in the share of vertical intra-industry trade, as shown in Figure

investment to avoid the simultaneity problem.

5.[30]

The model to test the above hypothesis is

$$S^{V}_{jit} = \alpha + \beta_1 \ln\left|yc_{jt} - yc_{it}\right| + (\beta_2 + \beta_3 im_{ji,t-1}) \times \ln f_{ji,t-1} + v_{jit} \qquad (4\text{-}3)$$

where im_{jit} denotes the intermediate product dummy variable,[31] which takes 1 if the ratio of intermediate product value to total vertical intra-industry trade value between Japan and country i in year t exceeds 50 percent. Otherwise, it takes 0.

If the parameter β_3 on the cross-term of the fourth variable in the right side of (4-3) is estimated positive and statistically significant, a positive relationship between the share of vertical intra-industry trade and the foreign direct investment is strengthened as the share of intermediate product to total trade is higher. This suggests that foreign direct investment has a close relationship with an increase in the share of vertical intra-industry trade, where the process division of labor within the machinery industry is active.

Finally, we estimate the following model, in which the cross-term consisting of the Asian-dummy, intermediate product dummy, and foreign direct investment variables is included, to test whether the above two hypotheses hold together:

$$S^{V}_{jit} = \alpha + \beta_1 \ln\left|yc_{jt} - yc_{it}\right| + (\beta_2 + \beta_3 ad \times im_{ji,t-1}) \times \ln f_{ji,t-1} + v_{jit} \qquad (4\text{-}4)$$

If the parameter β_3 on the cross-term of the fourth variable in the right side of (4-4) is estimated to be positive and statistically significant, the positive relationship between the share of vertical intra-industry trade and foreign direct investment is strong when Japan's trading partners are the Asian countries *and* the process division of labor within machinery industry is active.

4.3 *Data and Estimation Procedure*

(1) Data

The sample period of the data for empirical study is from 1989 to 2000; foreign direct investment is on the fiscal year basis and other variables are on the calendar year basis. Japan's trading partners consist of 15 countries, excluding Hong Kong, from the

[30] Especially in the Asian region, a global division of labor has been established across production blocks where long production processes are fragmented in detail. Therefore, it is natural to assume that intra-industry trade of parts has intensified even in the disaggregated commodity classification of the 6-digit HS codes.

[31] The intermediate product dummies in (4-3) and (4-4) are used as one period lagged to avoid the simultaneity bias with trade, which possibly occurs between trade and foreign direct investment as well.

aforementioned 16 countries.[32]

- Share of vertical intra-industry trade (S^V): the share of vertical intra-industry trade in Japan's machinery sector measured in Section 2. The share ranges from 0 to 1 so that we use the logistic transformed variable in the estimation as follow:

$$S^V = \ln[\frac{\hat{s}^V}{1-\hat{s}^V}]$$

where $\hat{s}^V$ is the share of vertical intra-industry trade measured in Section 2 (from 0 to 1).

- Real GDP per capita (yc): PPP adjusted real GDP per capita obtained from the "*Penn World Table 6.1*"[33] by the Center for International Comparisons at the University of Pennsylvania.

- Foreign direct investment (f): the sum of Japan's foreign direct investment values in machinery sectors, i.e., "general machine," "electric machine," and "precision machine," from the "Foreign Direct Investment" by the Ministry of Finance. They are deflated by the average of export and import price indices in machinery sector from the "Corporate Price Index" by the Bank of Japan. No stock values are available so that the accumulated values of foreign direct investment flows from 1989 are used.[34]

We confirm the descriptive statistics of the above variables in Table 2. First, the averages of the share of vertical intra-industry trade largely exceed those of the share of horizontal intra-industry trade despite Japan's trade partner regions. In addition, the differences in real GDP per capita between Japan and the Asian countries are larger than those between Japan and the developed countries, reflecting that the differences in factor endowment, i.e., the differences in capital/labor ratio, between Japan and the Asian countries exceeds those between Japan and the developed countries. Finally, the foreign direct investment toward the U.S. is overwhelmingly high; except for the U.S., however, the foreign direct investments toward the Asian countries are almost the same levels as those toward the developed countries. Nonetheless, the annual rate of increase in foreign

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[32] The trade with Hong Kong is eliminated from the sample of our empirical study. Because Hong Kong has an aspect as base of the "round-about trade" in which China is the final destination or the place of purchase, we have judged that trade with Hong Kong is not appropriate to analyze the determinant of bilateral trade.

[33] A. Heston, R. Summers and B. Aten, Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania, October 2002. The data is from the university website (http://pwt.econ.upenn.edu/).

[34] Although "Foreign Direct Investment" by the Ministry of Finance represent the official statistics of Japan's direct investment, it has some drawbacks: its industry classification is not given in detail, and the retirement and withdrawal of Japanese firms are not taken into account. The procedures to create a real variable of foreign direct investment and its accumulated values follow those of the forecited Koike (2004) and Kiyota (2003), respectively. It is especially difficult to create a real variable for foreign direct investment. Therefore, we have also estimated the model with the nominal value of foreign direct investment or its accumulated numbers instead of the real value, and checked the robustness of the results. We have obtained similar estimation results to the ones reported in this paper (the results are abbreviated).

direct investment toward the Asian countries is 20.7 percent on average while that toward the developed countries is 14.0 percent, indicating the active advances of Japanese firms toward Asia in the 1990s.

(2) Estimation Procedure

According to the preceding literature, it has been pointed out that individual effects between trading partners should be controlled for estimating the share of intra-industry trade.[35] These individual effects are likely to include any factors influencing the share of intra-industry trade such as geographical distances, differences in cultures and languages between trading partners, and trade barriers.[36] In addition, the time effects, i.e., the factors commonly affecting any bilateral trade, such as worldwide abolishment of trade barriers along globalization or an information-technology shock,[37] should also be taken into account.

The panel estimation is performed by specifying the error term v_{jit} from (4-1) to (4-4) as follows, applying such individual and time effects into the model:

$$v_{jit} = \mu_{ji} + \lambda_t + \varepsilon_{jit}$$

where μ_{ji} is an individual effect in bilateral trades; λ_t is a time effect; and ε_{jit} denotes an idiosyncratic shock.

In the panel estimation, we estimate both fixed-effects and random-effects models, selecting the appropriate one by the Hausman test.[38]

4.4 *Estimation Results and Discussions*

Table 3 shows the results of the empirical study from (4-1) to (4-4). First, according to the estimation results of the baseline model, i.e., models (1) and (3), the parameters on the differences in real GDP per capita are estimated to be positive and statistically significant in both models. This supports the hypothesis grounded in traditional trade theory that the share of vertical intra-industry trade becomes high when the difference in

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[35] See, e.g., Hummels and Levinsohn (1995), Durkin and Krygier (2000), among others.

[36] These kinds of factors are not explicitly dealt with under free trade assumptions in the theoretical model here.

[37] The Asian countries, including China, have gained importance as the production and export bases of electric machinery products, including information-technology products. Under such a global division of labor, when a demand shock occurs in one country, for example in the United States, its effects may pervade not only in bilateral trade between Japan and the country but also in those between Japan and other countries, especially the Asian countries. See Sasaki (2004) for a case study on Japan's trade.

[38] The significance of time effects is judged by the specification tests: i.e., the *F*-test and the likelihood ratio test.

factor endowment between trading partner is large.[39] Next, the parameter on foreign direct investment is also estimated to be positive and statistically significant in models (2) and (3). This supports the hypothesis that foreign direct investment has played a role in increasing in the share of vertical intra-industry trade.

We now evaluate the effects of cross-terms consisting of foreign direct investment and kinds of dummy variables. First, the parameter on the cross-term consisting of Asian-dummy and foreign direct investment, $ad \times \ln f_{ji,t-1}$, is estimated to be positive and statistically significant in model (4). This supports the hypothesis that a positive relationship between the share of vertical intra-industry trade and foreign direct investment is strong, especially in trade with the Asian countries. Further, the parameter on the cross-term consisting of intermediate product dummy and foreign direct investment, $im_{ji,t-1} \times \ln f_{ji,t-1}$, is also estimated to be positive and statistically significant in model (5). This intimates that the foreign direct investment has increased the share of vertical intra-industry trade where the process division of labor within the machinery industry is active. Incidentally, the intermediate product dummy variable used in the above estimation takes 1 when the ratio of intermediate product to total vertical intra-industry trade between trading partners exceeds 50 percent; otherwise, it takes 0. To check the robustness of the above estimation results, we have also created intermediate product dummy variables, which take 1 when the ratio exceeds 40 percent or more than 30 percent, respectively; then models with the cross-terms consisting of these intermediate product dummies and foreign direct investment are estimated. As a result, similar estimation results to which we have already reported above are obtained (estimation results are abbreviated). Finally, the parameter on the cross-term consisting of the Asian and intermediate product dummies and foreign direct investment, $ad \times im_{ji,t-1} \times \ln f_{ji,t-1}$, is estimated to be positive and statistically significant in model (6). This suggests that a positive relationship between the share of vertical intra-industry trade and foreign direct investment is closer when Japan's trading partners are the Asian countries and the process division of labor within the machinery industry is more active.

According to a series of results on the above empirical studies, it is confirmed that both the difference in factor endowment between Japan and its trading partners, as traditional trade theory suggests, and the formulation of global production system by Japan's multinational firms through their foreign direct investment toward the Asian countries have played key roles for the determinants of the recent trade pattern in Japan's machinery sector.

[39] The forecited Fukao *et al.* (2003) have obtained consistent results with our empirical study that a positive relationship exists between share of vertical intra-industry trade and differences in real GDP per capita in the bilateral trades with the countries of which real GDP per capita differs from Japan's real GDP per capita by more than approximately 10,000 international dollars. Fukao *et al.* have estimated 43 of Japan's bilateral trades including the Asian countries, and the estimation method is by least square, with instrumental variables.

5. Concluding Remarks

This paper has analyzed patterns of trade in Japan's machinery sector.

First, we used disaggregated data consisting of Japan's export and import commodities—which are classified with 6-digit HS codes—to examine trade patterns. This procedure allows us to divide the total trade in machinery sector into three trade patterns: inter-industry trade (i.e., the one-way trade), vertical intra-industry trade (i.e., the two-way trade of products differentiated by their qualities), and horizontal intra-industry trade (i.e., the two-way trade of products differentiated by their attributes), respectively. According to the calculated share of each trade pattern to total trade in Japan's machinery sector, it is found that while the share of inter-industry trade declined in the 1990s, the share of vertical intra-industry trade increased significantly during the period. This tendency is prominently observed in the trade with the Asian countries. Next, the background of the increase in vertical intra-industry trade in Japan's machinery sector was examined in the framework of traditional trade theory. It was shown that vertical intra-industry trade occurs between domestic and foreign industries when the trading partners specialize in manufacturing products differentiated by their qualities according to their comparative advantages. It has also been discussed that the direct investment of the home country overseas has an effect on vertical intra-industry trade between them through the accumulation of capital in the foreign industry. Finally, the empirical study on the determinants of trade patterns in Japan's machinery sector was performed using panel data consisting of 15 countries from 1989 to 2000. The empirical result has shown that the share of vertical intra-industry trade has been closely related to the differences in the capital/labor ratio between Japan and its trading partners, and to Japan's foreign direct investment toward those countries. It is also found that the positive relationship between the share of vertical intra-industry trade and foreign direct investment is strong when Japan's trading partners are the Asian countries, and when the process division of labor within the machinery industry is more active.

The analysis in this paper has confirmed that both the difference in factor endowment between Japan and its trading partners and Japan's foreign direct investment have played key roles in the marked increase in trade in Japan's machinery sector in the 1990s. For the past few years, it has been observed that some Japan's manufacturing firms have moved their production bases back to their home countries, due to the progress in domestic corporate restructuring or to the recovery of the domestic economy. However, considering that the Asian region, including China, has been gaining importance as a global production site under economic globalization, it should be said that both exports and imports in Japan's machinery sector are going to move in the same direction for the time being, which may also hold true for trade, especially with the Asian countries.

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Table 1: Shares of Trade Patterns by Countries

Rates of changes from 1990 to 2000 are in percentage points.

	Share of intra-indusrty trade				Share of vertical intra-industry trade				Share of horizontal intra-industry trade			
	1990CY	1995CY	2000CY	Rate of change from 90-00	1990CY	1995CY	2000CY	Rate of change from 90-00	1990CY	1995CY	2000CY	Rate of change from 90-00
China	0.18	0.47	0.60	0.42	0.16	0.35	0.45	0.29	0.02	0.12	0.15	0.13
South Korea	0.45	0.45	0.56	0.11	0.32	0.40	0.53	0.21	0.13	0.05	0.02	-0.11
Taiwan	0.44	0.52	0.51	0.07	0.37	0.34	0.47	0.10	0.07	0.18	0.04	-0.04
Hong Kong	0.17	0.29	0.10	-0.07	0.14	0.28	0.06	-0.08	0.03	0.01	0.04	0.01
Singapore	0.29	0.53	0.58	0.29	0.22	0.20	0.54	0.32	0.06	0.32	0.04	-0.02
Thailand	0.30	0.32	0.51	0.20	0.27	0.29	0.40	0.13	0.03	0.04	0.11	0.08
Malaysia	0.33	0.39	0.52	0.19	0.28	0.35	0.44	0.16	0.05	0.04	0.07	0.02
the Philippines	0.29	0.48	0.62	0.33	0.27	0.47	0.51	0.23	0.02	0.00	0.11	0.10
Indonesia	0.04	0.14	0.42	0.38	0.04	0.13	0.28	0.24	0.00	0.01	0.14	0.14
the U.K.	0.34	0.40	0.38	0.04	0.32	0.36	0.36	0.04	0.03	0.03	0.03	0.00
the Netherlands	0.09	0.24	0.09	0.00	0.08	0.23	0.08	0.00	0.01	0.01	0.01	0.00
Belgium	0.08	0.12	0.10	0.02	0.08	0.12	0.09	0.02	0.01	0.00	0.01	0.01
France	0.25	0.34	0.37	0.12	0.22	0.31	0.34	0.12	0.02	0.03	0.03	0.00
Germany	0.31	0.38	0.46	0.15	0.26	0.35	0.32	0.06	0.05	0.03	0.14	0.09
Canada	0.15	0.22	0.33	0.17	0.13	0.20	0.30	0.17	0.02	0.02	0.02	0.00
the U.S.	0.56	0.63	0.63	0.06	0.54	0.58	0.46	-0.09	0.02	0.04	0.17	0.15
Overall averages	0.27	0.36	0.41	0.14	0.24	0.31	0.35	0.11	0.04	0.05	0.07	0.03

Table 2: Descriptive Statistics of the Variables

(1) All Countries

	Share of vertical intra-industry trade	Share of horizontal intra-industry trade	Difference in real GDP per capita ($)	Foreign direct investment (bil. yen)
Average	0.30	0.05	8,727	213
Median	0.31	0.04	4,777	84
S.D.	0.14	0.05	7,239	507
Min.	0.04	0.00	166	1
Max.	0.58	0.32	22,081	4,097

(2) By Region

<Asian countries>

	Share of vertical intra-industry trade	Share of horizontal intra-industry trade	Difference in real GDP per capita ($)	Foreign direct investment (bil. yen)
Average	0.34	0.07	13,955	103
Median	0.34	0.05	15,152	70
S.D.	0.12	0.06	6,098	104
Min.	0.04	0.00	339	1
Max.	0.57	0.32	22,081	491

<Developed countries except for the U.S>

	Share of vertical intra-industry trade	Share of horizontal intra-industry trade	Difference in real GDP per capita ($)	Foreign direct investment (bil. yen)
Average	0.22	0.03	2,326	119
Median	0.24	0.02	2,347	71
S.D.	0.11	0.03	1,021	115
Min.	0.06	0.00	166	3
Max.	0.48	0.15	4,626	515

<the U.S.>

	Share of vertical intra-industry trade	Share of horizontal intra-industry trade	Difference in real GDP per capita ($)	Foreign direct investment (bil. yen)
Average	0.53	0.08	5,301	1,651
Median	0.53	0.05	4,730	1,213
S.D.	0.04	0.07	2,283	1,257
Min.	0.46	0.01	2,513	284
Max.	0.58	0.20	9,694	4,097

Notes.

1. The descriptive statistics are values from 1989 to 2000.
2. The shares of vertical and horizontal intra-industry trades are values before logistic transformations. Differences in real GDP per capita and foreign direct investment are values before logarithmic tranformation.

Table 3: Panel Estimation Results on the Determinants of Trade Pattern

Sample period: 1989-2000CY

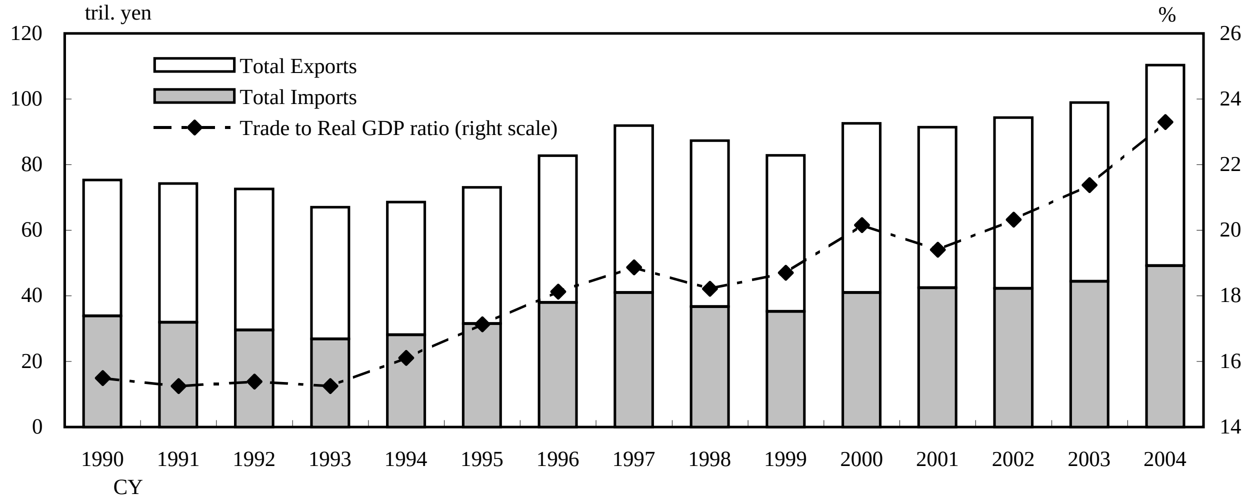
Explanatory variables		Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
		Dependent variable: S^{V}_{jit} Share in vertical intra-industry trade					
Difference in factor endowment							
$\ln\lvert yc_{jt} - yc_{it}\rvert$	Difference in real GDP per capita	0.176**		0.125*	0.097*	0.093*	0.114*
		(0.060)		(0.052)	(0.051)	(0.049)	(0.049)
Foreign direct investment							
$\ln f_{ji,t-1}$	Foreign direct investment		0.340**	0.343**	0.146**	0.368**	0.285**
			(0.028)	(0.027)	(0.046)	(0.048)	(0.029)
$ad \times \ln f_{ji,t-1}$	Asian-Dum. *Foreign direct investment				0.285**		
					(0.056)		
$im_{ji,t-1} \times \ln f_{ji,t-1}$	Intermediate product Dum. *Foreign direct investment					0.015**	
						(0.003)	
$ad \times im_{ji,t-1} \times \ln f_{ji,t-1}$	Asian-Dum.*Intermediate product Dum. *Foreign direct investment						0.014**
							(0.003)
S.E.		0.33	0.30	0.29	0.27	0.27	0.28
F-stat.		30.84	67.95	65.08	73.20	48.29	68.33
Hausman-test		0.01	0.13	1.01	22.18	5.67	2.32
(p-value)		(0.91)	(0.72)	(0.60)	(0.00)	(0.13)	(0.51)
Estimation Model		Two-way random effects model	One-way random effects model	One-way random effects model	One-way fixed effects model	Two-way random effects model	Two-way random effects model
Number of obs.		165	165	165	165	165	165

Notes.

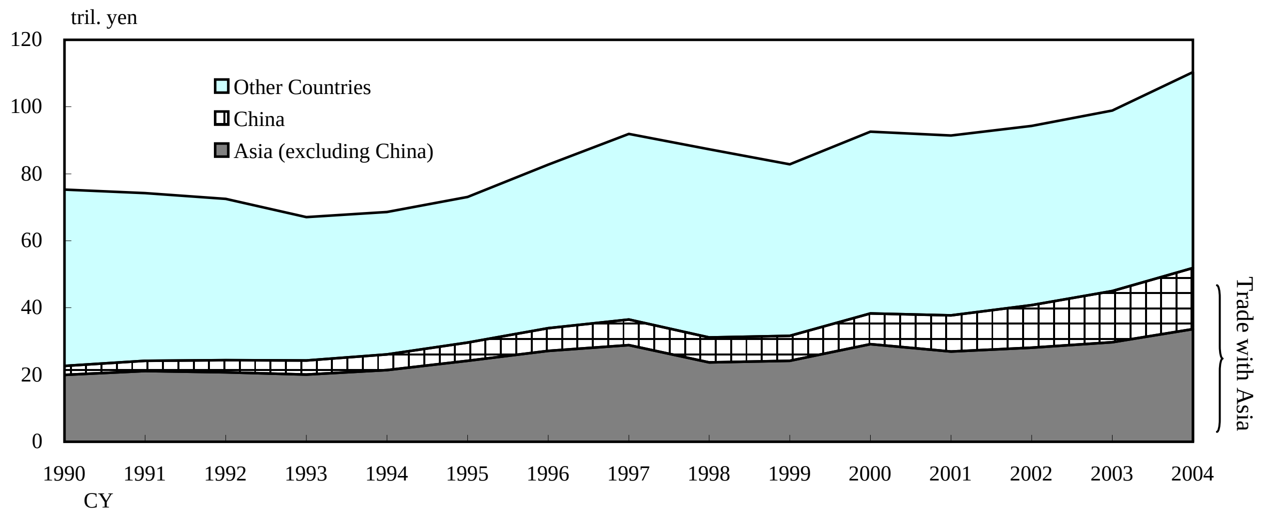
1. Figures in parentheses below the parameter estimates are standard deviations. ** and * indicate significance levels of 1 and 5%, respectively. The constant terms are not reported.
2. Estimation models are chosen by model specification tests. Random-effects models are estimated by the FGLS (Feasible Generalised Least Squares).

Figure 1: Overview of Japan's Trade

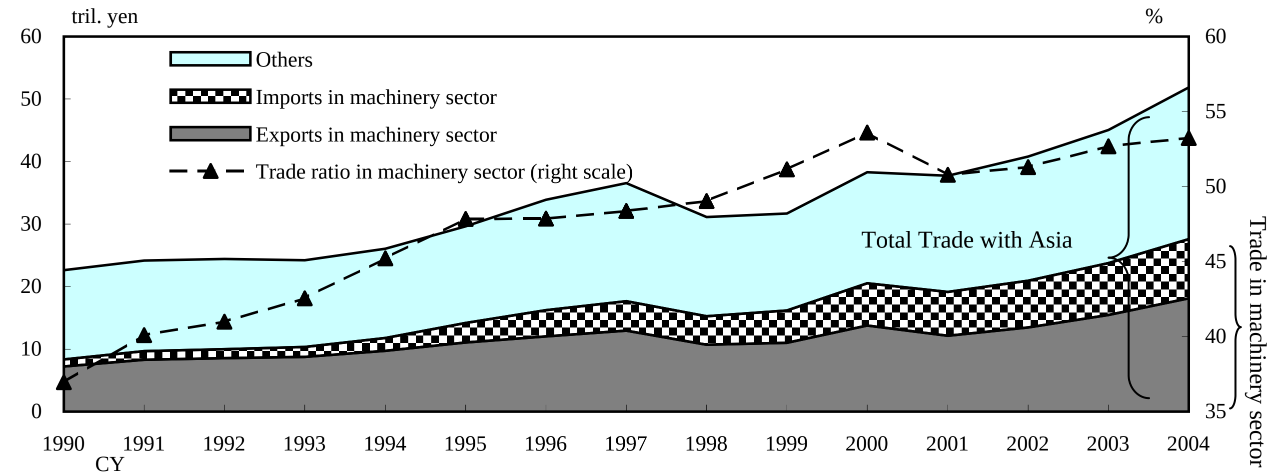
(1) Total Exports and Imports



(2) Exports and Imports by Region



(3) Trade with the Asian Countries in Machinery Sector



Notes.

1. Trade to Real GDP ratio in (1) is the ratio of sum of real exports and real imports to total real GDP.
2. Trade ratio in machinary sector in (3) is the ratio of trade in machinary sector to Japan's total trade with Asia.

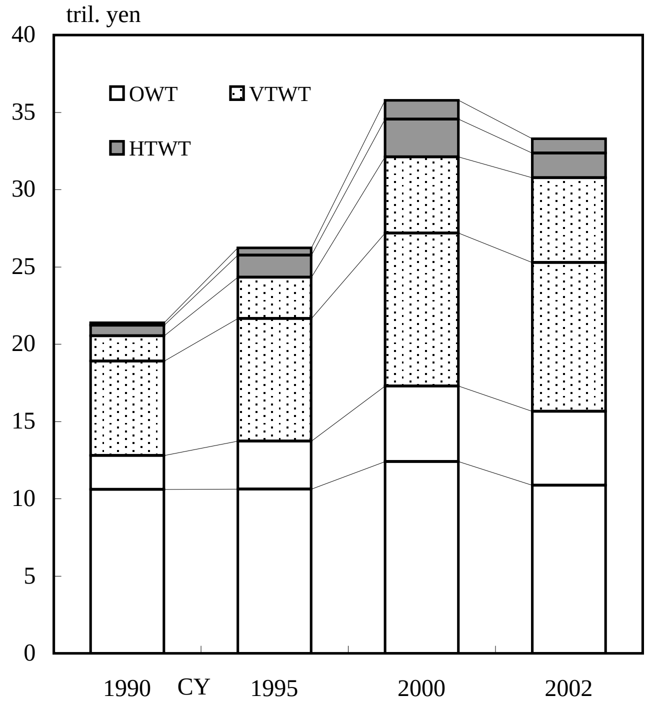
Sources.

Cabinet Office "System of National Accounts,"
Japan Tariff Association "Summary Report on Trade of Japan"

Figure 2: Trade Pattern in Machinery Sector

(1) Total Trade

<Value>



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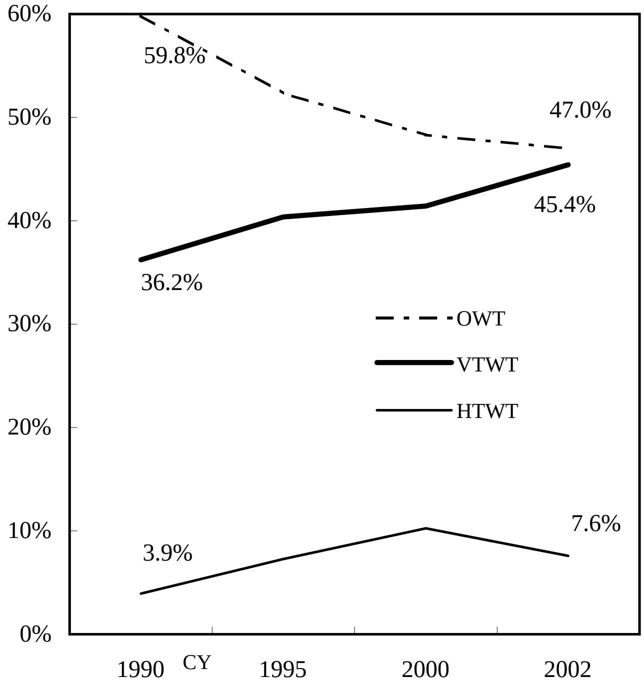
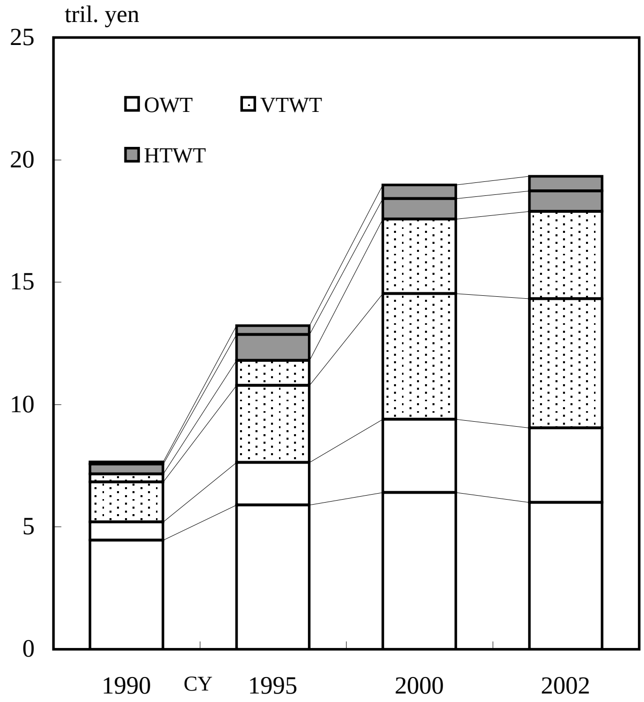


(2) Trade with Asia

<Value>



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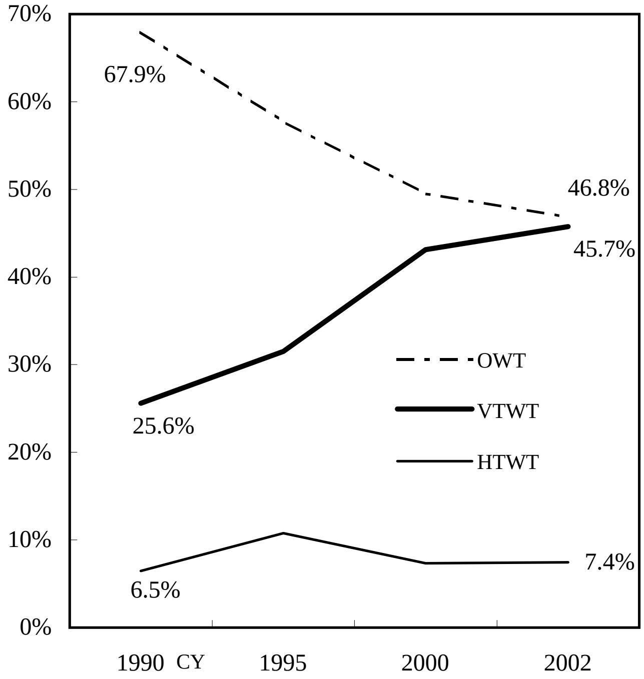


Notes.

1. OWT, VTWT, and HTWT represent the inter-industry, vertical intra-indusrty, and horizontal intra-industry trades, respectively.
2. The upper and lower rows in each value of trade pattern in the pole graph denote import and export values, respectively.

Figure 3: Vertical Intra-Industry Trade Model

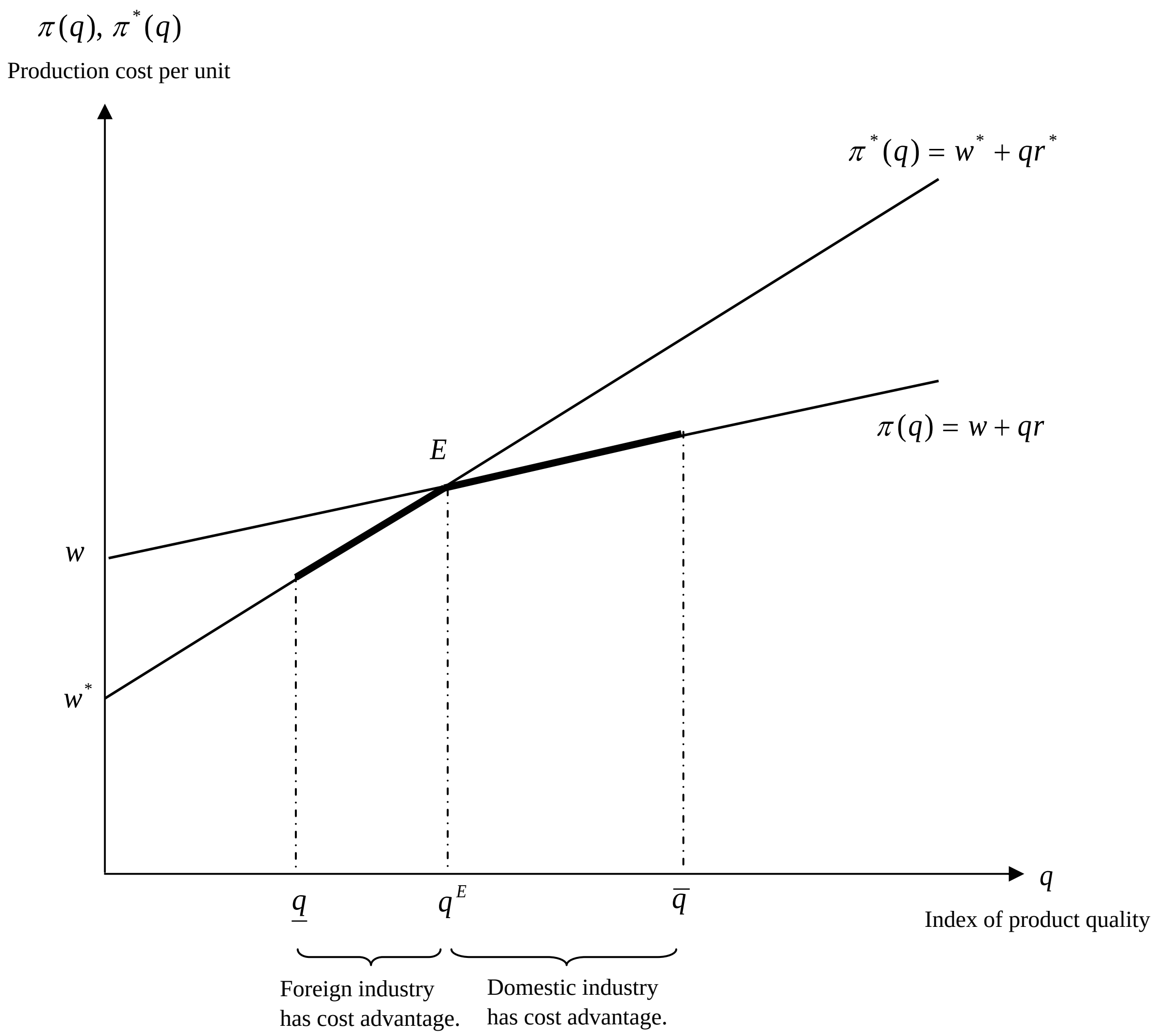


Figure 4: Effects of an Increase in Foreign Capital

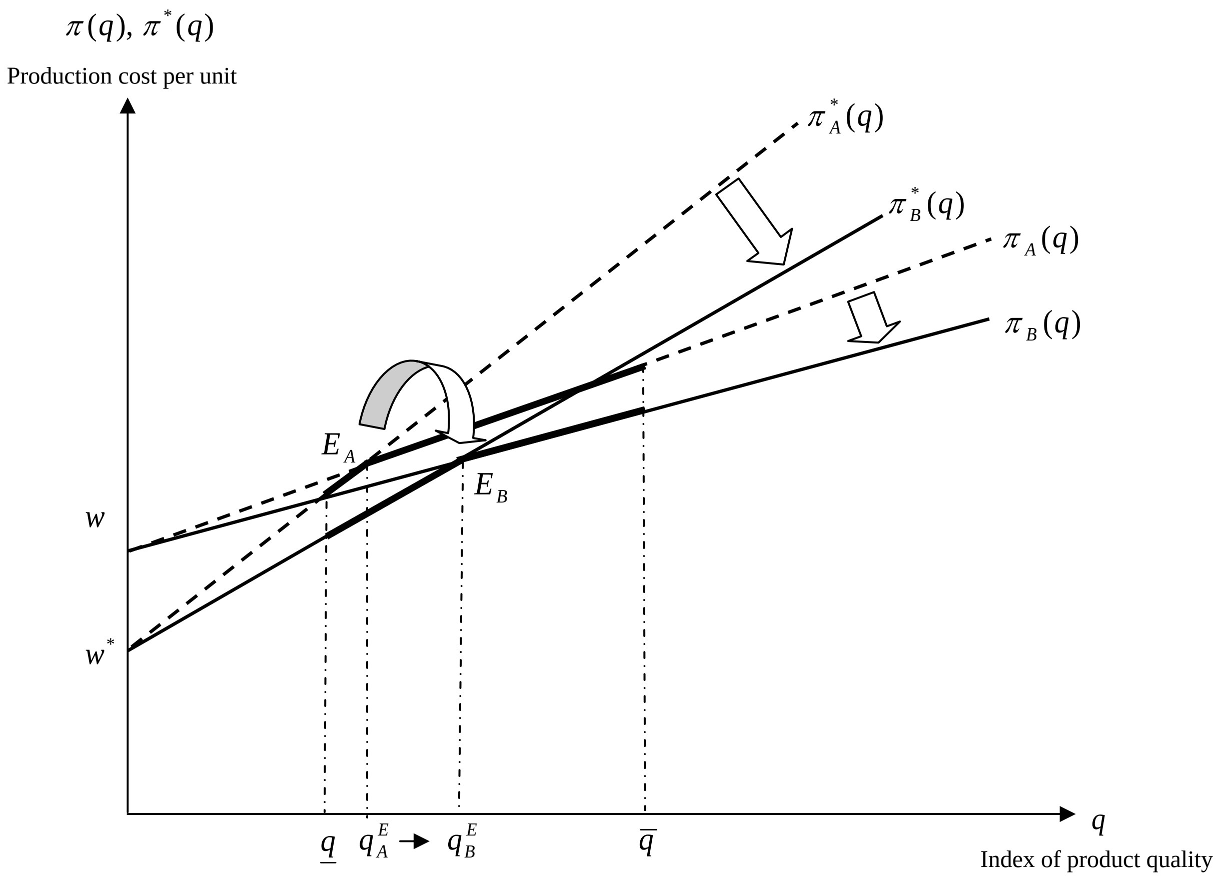
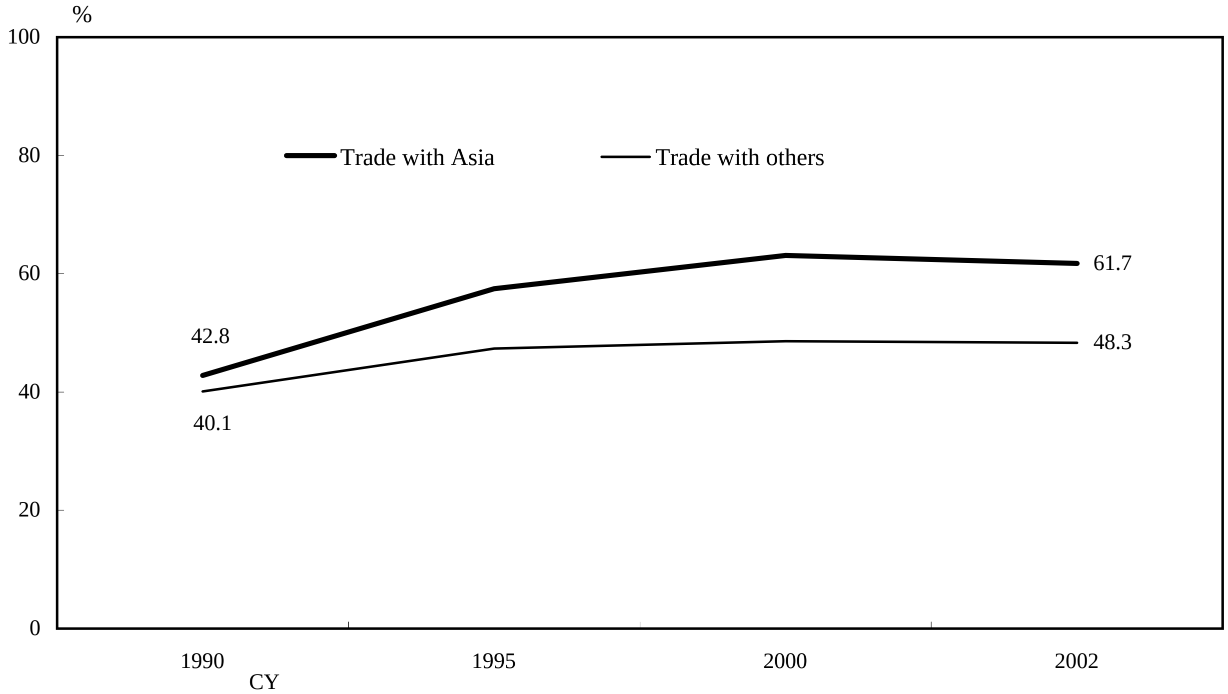


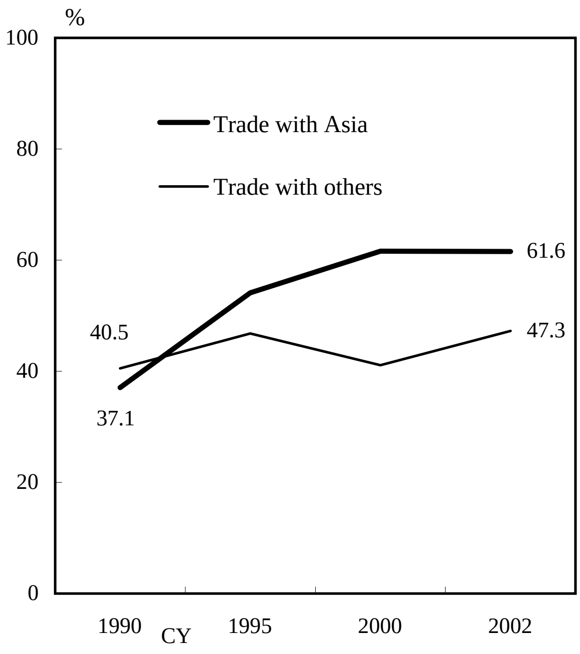
Figure 5: Intermediate Product Ratio in Machinery Sector

(1) Ratio of Intermediate Product to Intra-Industry Trade

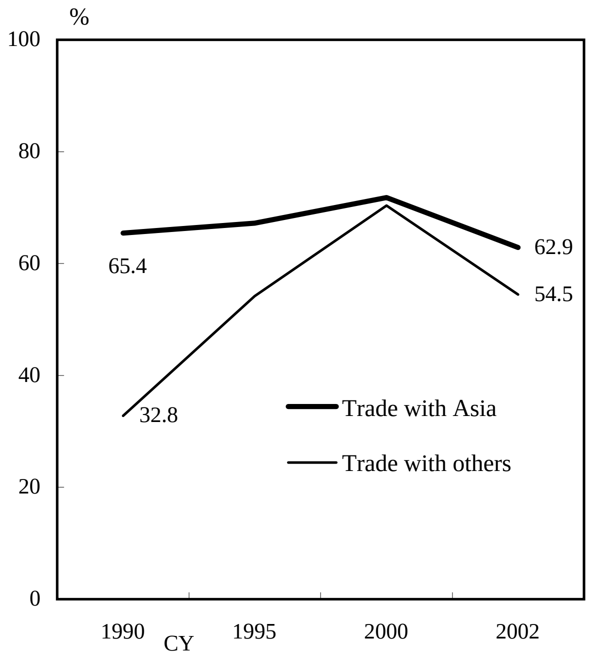


(2) Intermediate Product Ratio by Trade Pattern

<Ratio in vertical intra-industry trade>



<Ratio in horizontal intra-industry trade>



Note.

Intermediate products aggregate the parts and partly finished goods classified by the 6-digit HS codes in Japan's trade statistics.