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Global Supply Chains in Machinery Trade and
the Sophisticated
Nature of Production/Distribution Networks in East Asia

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Abstract

本論文では、東アジアにおける国際分業体制に関する理論的な分析枠組みを提示し、国際貿易および企業レベルでの統計を用いてその実証的検証を行っている。近年の東アジアでは、機械産業を中心に精緻な生産ネットワークが形成されており、本分析によってその多くの特徴が明らかになった。東アジアの国際経済市場を記述する適切な理論モデルの形成・発展が急務である現在、こうしたファクトの積み重ねは、その理論モデル形成において重要な役割を担うと考えられる。

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“Global Supply Chains in Machinery Trade and the Sophisticated Nature of
Production/Distribution Networks in East Asia”*

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Abstract

The most salient phenomenon in recent international trade in East Asia is the formation of international production/distribution networks. This paper applies the two-dimensional fragmentation framework (Kimura and Ando (2005)) to investigate the structure and characteristics of international production/distribution networks. Two important issues are investigated. The one is how the formation of international production/distribution networks, particularly in machinery industries, has changed the overall pattern in East Asian trade, both intra-regional and inter-regional. We find that about a half of intra-regional export expansion of East Asian countries in 1990-2003 is induced by the increase in trade in machinery parts and components, which suggests the existence of large “magnification” effect in intra-regional trade volumes. The relative importance of markets outside East Asia, notably North America and EU markets, seems to rather decline a bit due to the expansion of East Asian markets themselves. Another issue is how corporate firms effectively combine two kinds of fragmentation, i.e., fragmentation in terms of geographical distance and disintegration. The statistical data of affiliates of Japanese firms in East Asia indicate that transactions with Japan are likely to be intra-firm, while transactions in local market tend to be arm’s-length (inter-firm), which is consistent with our analytical framework claiming a close link between geographical proximity and outsourcing. Finally, the Baldwin-Kimura approach (Baldwin and Kimura (1998)) is applied to present the worldwide picture of production/distribution networks of Japanese firms.

1. Introduction

It has been widely recognized in the academic/semi-academic literature of both international trade and development economics that the formation of international production/distribution networks in East Asia is an extremely important, novel phenomenon. The pattern of industrial location and international trade in East Asia is not a typical North-South pattern anymore. Vertical intra-industry trade, particularly in machinery industries, explosively increases, while the European-type horizontal intra-industry trade is rarely observed. De facto economic integration certainly proceeded in East Asia, but the path is not necessarily following the experience of the predecessors such as EU. It is a challenge for both academicians and policy makers to understand what happens in East Asia.

The formation of international production/distribution networks is a quite recent phenomenon, only starting in the 1990s, and undermines or at least partially nullifies a large class of old theories and hypotheses. The influential “East Asian Miracle” report, i.e., the World Bank (1993), was written before the development of production networks, and thus the analysis failed to emphasize the crucial role of foreign direct investment (FDI) in development. The old “export platform” argument claimed Japanese production operations in East Asia as a strategy for circumventing trade disputes with the US and other markets. Such a story, however, currently explains only a small portion of international production/distribution networks in East Asia. Now, players in the production networks are not only Japanese firms, and the expansion of East Asian market itself is significant.

How about the flying geese pattern argument? It cannot be applied anymore to the currently observed international location patterns of manufacturing sectors in the sense that they are dominated by more subtle production-process-wise location patterns, not by industry-by-industry location patterns. A simple link between development stages and competitive industries does not hold anymore. How about discussion on industrial promotion policy or MITI-type picking-winner policies? Such an old-fashioned industrial policy for import substitution is not at the center of policy discussion anymore. The focus of industry promotion policy by developing countries is placed on how to connect indigenous firms with international production/distribution networks. What would be the desired format of economic integration in East Asia? A new policy package must be included in the FTA framework in order to further promote

international production/distribution networks. These are all novel arguments and discussion in East Asia.

The authors proposed a conceptual framework of two-dimensional fragmentation in the previous work (Kimura and Ando (2005)). It provides a useful analytical approach to understand the mechanics of international production/distribution networks in East Asia. It well explains location patterns of fragmented production blocks across countries with different location advantages, emphasizing the importance of service link that connects remotely located production blocks. Moreover, it effectively describes the logic of production/distribution networks extending beyond the boundary of firm. Arm's-length (inter-firm) fragmentation is an essential element in the formation of agglomeration, and such sophisticated networks in turn provide opportunities for indigenous firms penetrating into production networks developed by multinational enterprises (MNEs).

As an extending analysis, this paper is devoted to some of the unsolved questions in connection with the conceptual framework and empirics of the international production/distribution networks. The first is how the formation of international production/distribution networks, particularly in machinery industries, has changed the overall pattern in international trade, both intra-regional and inter-regional. Are the US and EU markets getting to be less important with the expansion of East Asian market itself? How big is the "magnification" effect of parts and components trade in the expansion of East Asian intra-regional trade? The paper looks into these points regarding the first question.

The second question is how corporate firms effectively combine two kinds of fragmentation. In transactions among Japan, NIEs, ASEAN, and China, is there any systemic pattern of intra-firm or arm's-length transactions? Do we observe significant changes over time? Although it is extremely difficult to comprehend these aspects of networks in statistics, the analysis using the micro data of Japanese affiliates can provide us some clues.

The paper plan is as follows: the next section reviews the framework of two-dimensional fragmentation and establishes the link with empirical studies conducted in the paper. Section 3 presents the overall picture of intra-regional and inter-regional trade of East Asian countries. Section 4 concentrates on machinery industries and analyzes the nature of fragmentation in two dimensions, i.e., distance and

disintegration, by using the micro data of Japanese affiliates abroad. Section 5 employs the Baldwin-Kimura approach and presents the estimated pattern of transactions among three geographical locations (Japan, Asia, and the rest of the world) and three firm nationalities (Japanese, Asian, and others). The last section concludes the paper.

2. Conceptual framework of two-dimensional fragmentation

The formation of international production/distribution networks has fundamentally changed the pattern of production location and international trade in East Asia. Although networks can be formulated in various industries, most important, both qualitatively and quantitatively, are those in machinery industries including general machinery, electric machinery, transport equipment, and precision machinery. Machinery industries deal with a large number of multi-layered vertical production/distribution processes, and East Asian firms including Japanese firms have a competitive edge in exploring modulation techniques and constructing vertical value chains. International production/distribution networks in East Asia are distinctive and most developed in the world at this point in time in (i) their significance in each economy in the region, (ii) their extensiveness covering a number of countries in the region, and (iii) their sophistication in subtle combination of intra-firm and arm's-length (inter-firm) transactions.¹

The literature of the fragmentation theory and its empirical applications has grown since a seminal work by Jones and Kierzkowski (1990) and proved its applicability in analyzing cross-border production sharing at the production process level.² International production/distribution networks in East Asia, however, have developed beyond the original idea of fragmentation, and some expansion of the analytical framework is needed in order to incorporate intra-firm and arm's-length transactions. Kimura and Ando (2005) propose the concept of two-dimensional fragmentation, in particular to analyze the mechanics of production networks in East Asia.

Figure 1 illustrates a simple version of Maquila operation in the US-Mexico

¹ See Ando and Kimura (2005).

² Also see Arndt and Kierzkowski (2001), Deardorff (2001), and Cheng and Kierzkowski (2001) for the fragmentation theory.

nexus. Cross-border production sharing between the US and Mexico is mostly a simple intra-firm fragmentation, accompanied with back-and-forth intra-firm transactions between headquarters in the US and an affiliate in Maquila, Mexico. A typical pattern is as follows: parts and components are sent from US headquarters to a factory in Mexico, the assembly process is conducted there, and the finished products are sent back to the US headquarters. On the other hand, production/distribution networks in East Asia contains a much more complicated combination of intra-firm and arm's-length transactions across a number of countries in the region. Figure 2 is drawn with reference to an actual example of a Japanese manufacturer in electronic machinery industry, extending production/distribution networks all over East Asia and the US. The framework of two-dimensional fragmentation tries to capture such a sophisticated structure of international production/distribution networks.

Figure 1

Figure 2

Figure 3 presents fragmentation in a two-dimensional space. The horizontal axis denotes geographical distance. From the original position, a production block can be detached and placed in geographical distance. A dotted line in the middle is a national border, which distinguishes cross-border fragmentation from domestic fragmentation. On the other hand, the vertical axis represents the organization (integration and disintegration) of corporate activities. A fragmented production may be conducted by either intra-firm establishments or unrelated firms. The dotted line is a boundary of firm, distinguishing arm's-length (inter-firm) fragmentation or outsourcing from intra-firm fragmentation.³

³ Disintegration and accompanied transaction cost have been long analyzed in the industrial organization literature on vertical integration. As for the references on Japanese subcontracting system, particularly corporate firms' choices over vertical integration, subcontracting, and spot market bidding in parts and components procurement, see Kimura (2002). For the renewed interest in the global context, see, for instance, Grossman and Helpman (2003), Grossman and Helpman (2004), Grossman and Helpman (2005), Grossman, Helpman, and Szeidl (2005), which are based on the framework of contract theories.

Figure 3

When do corporate firms choose fragmentation? First, there must be a substantial cost reduction in the production of fragmented production blocks (see Table 1). Geographical distance may provide opportunities to explore different production conditions. In particular, cross-border fragmentation enables firms to enjoy diversified location advantages including workers' wages, economic infrastructure, policy environment, and others. The disintegration axis would yield chances to utilize business partners' strengths. Instead of doing everything in house, arm's-length fragmentation or outsourcing may make the whole production system more efficient. Second, service link cost for the connection between fragmented production blocks should not be too high. Fragmentation beyond national border and/or boundary of firm is inevitably accompanied by substantial service link cost, but such cost must be low enough to enjoy the total cost reduction.

Table 1

Service link cost changes as illustrated in Figure 4 when fragmentation takes place along the distance or disintegration axis. When fragmentation occurs in the horizontal direction as [i] and [ii] in Figure 3, service link cost increases according to distance from the original position. In particular, once fragmentation crosses national border, service link cost jumps up because of the national border effect. When fragmentation takes place in the vertical direction as [iii] and [iv], service link cost increases as the controllability of a firm over the fragmented production block gets weaker. Various types of outsourcing along the disintegration axis from subcontracting to internet auction are illustrated in Figure 4. An important observation here is that geographical proximity saves service link cost or transaction cost as [iii] is drawn much lower than [iv].

Figure 4

In East Asia, geographical fragmentation and agglomeration go hand in hand.

In contrast with market-oriented agglomeration in Europe, agglomeration in East Asia is often motivated by the production-side logic. The forces of fragmentation and agglomeration are countervailing in the first place; they are vectors pointing in the opposite directions. In particular, when a firm decides whether to make intra-firm fragmentation, fragmentation or agglomeration is a binary decision. However, at the industry/aggregate level, fragmentation and agglomeration may go together.

The concentration of fragmented production blocks occurs at least through the following two channels: first, two kinds of service link cost do not have a monotonic pattern, and local minimal points of service link cost tend to attract a large number of production blocks. Particularly in cases of less developed countries (LDCs), each country, each local province, each city, or each industrial estate has different investment climate. Service link cost is not monotonic at all in both dimensions of distance and disintegration. Moreover, service link is often accompanied with strong economies of scale. Therefore, when a country successfully reduces two kinds of service link cost by proper policies, fragmented production blocks may rush in, and service link cost may be pushed down further.

Second, the concentration of production blocks may also happen due to the close relationship between the service link cost along the disintegration axis and geographical proximity as indicated in Figure 4. The service link cost in arm's-length fragmentation is extremely sensitive to geographical distance. The closer the distance with business partners, the smaller the service link cost in searching potential business partners, consulting detailed specs of products, managing product quality and delivery timing, solving disputes over contracts, monitoring, and others. The northwest area in Figure 4 is a hot spot of this type of agglomeration. Here, the concentration of production blocks would reduce the service link cost, and the low service link cost would further attract production blocks; the arrows of causality would go in both directions. The concentrated production blocks in this mechanism generate interactive industrial structure among production blocks.

The two-dimensional fragmentation framework captures multilayered fragmentation as Figure 5. By shifting the original position from headquarters in the home country to an affiliate abroad, for example, the complicated structure of fragmentation with intra-firm and arm's-length transactions can be depicted.

Figure 5

3. The evolution of intra- and inter-regional trade

Now let us examine the first question: how the formation of international production/distribution networks in machinery industries has changed an overall pattern in international trade in East Asia, particularly the pattern of intra-regional and inter-regional trade.

Before focusing on intra- and inter-regional trade patterns, we demonstrate the significance of machinery trade in East Asia. Figures 6 and 7 presents the shares of machinery goods and machinery parts and components in total exports to and imports from the world at the beginning of and at the end of the 1990s and in 2003 for major economies in East Asia and other regions.⁴ The figures plot countries from the one with the highest export share of machinery parts and components, to address the relative significance of machinery intermediate goods trade.

Figure 6

Figure 7

As both figures vividly show, the share of machinery goods in East Asian countries drastically increased in terms of both absolute and relative terms. At the beginning of the 1990s, most countries with relatively high shares of machinery parts and components were developed countries such as Japan, the United States, U.K, and Germany. In 2003, however, East Asian developing countries moved up to the left side, presenting high shares of both machinery intermediate exports and imports. This implies the existence of back-and-forth transactions and growing export-oriented operations in those countries. The trade pattern of Japan also suggests drastic changes in trade and production patterns in the region; while a large portion of its machinery exports composed of machinery final goods in 1990, half of its machinery exports composed of machinery parts and components, with increased shares of their imports, in

⁴ See Table A.1 for a definition of machinery parts and components in this paper.

2003. In East Asia, inter-industry trade patterns between developed and developing countries seem to have considerably changed, and international production/distribution networks in machinery industries have been rapidly developed, involving a number of countries in the region.⁵

In other regions, in contrast, higher shares of machinery trade and those of machinery parts and components trade are observed for some specific countries such as the U.S., Mexico, U.K, Germany, Hungary, Czech Republic, and Slovakia. This suggests the development of production networks in machinery industries between the U.S. and Mexico and between U.K./Germany and Central and Eastern European countries, but these networks do not extensively cover a number of countries in the regions like East Asia. Other countries, particularly those in Latin America except Mexico, are found on the right side with far lower shares of machinery exports. In addition, the shares of machinery exports are much lower than those of imports, suggesting import-oriented operations.

Tables 2a-5a, in tern, present current-price exports of all products, machinery goods (total), machinery final goods, and machinery parts and components in East Asia including China, ASEAN4, NIEs3, and Japan in 1990, 2001, and 2003 and those in each country/group, by distinguishing intra-East Asian exports from inter-regional exports (expressed as “others”). To investigate the relative importance of U.S. market for East Asian exports in particular, corresponding figures are also displayed in parenthesis. Note that Taiwan, which would be one of important players in international production networks in machinery industries, is not unfortunately included in East Asia due to the lack of data available from UN COMTRADE, and thus the value and share of intra-East Asian trade would be underestimated in these tables.

Table 2

⁵Ando (2005) analyzes changes in East Asian trade structure in the 1990s by decomposing each country’s machinery trade (exports plus imports) with the world at the finely disaggregated level (HS six-digit) into one-way trade, vertical intra-industry trade (vertical IIT), and horizontal intra-industry trade (horizontal IIT), and emphasizes that vertical IIT, particularly vertical IIT in machinery parts and components, expanded. The explosive expansion of machinery intermediates trade indeed resulted in changes in main trade patterns in East Asia from one-way trade to vertical IIT.

Table 3

Table 4

Table 5

Clearly, the share of intra-East Asian exports in total exports (all products) by East Asia as a whole has risen, indicating the increasing relative importance, compared to the inter-regional exports. Such an increasing relative importance of intra-regional trade is more vividly observed in machinery trade, particularly machinery parts and components trade. In the case of machinery intermediates exports in East Asia as a whole, intra-regional shares climbed up to 58 percent in 2003 from 40 percent in 1990. The corresponding figures for Japan, NIEs³, ASEAN⁴, and China are 48 percent in 2003 (28 percent in 1990), 65 percent (54 percent), 60 percent (51 percent), and 56 percent (74 percent), respectively.⁶ These figures confirm enhancing relative significance of intra-regional trade pattern to inter-regional trade pattern in machinery industries, particularly in machinery parts and components trade. In other words, the importance of markets outside the region for East Asian exports, including U.S. market, has relatively declined. Considering the expanded domestic demand according to economic growth of East Asian countries, which is not appeared as transactions beyond national borders, the relative importance of intra-East Asian market would have been enhanced more notably than suggested by the above figures.

How fast intra-East Asian trade (inter-regional trade, East Asian trade) has grown in absolute terms since the 1990s, and what induced such an expansion of intra-East Asian trade? Tables 2b-5b (2c-5c, 2d-5d) present the growth from 1990 to 2003 in intra-East Asian exports (inter-regional exports, East Asian exports) for all products, total machinery goods, machinery final goods, machinery parts and components. During that period, intra-East Asian trade of all commodities expanded by

⁶ Although the intra-East Asian share for machinery parts and components has declined in China, the value of machinery intermediate exports itself explosively increased. Moreover, the U.S. share indeed increased to over 20 percent at the end of the 1990s from the low share of 10 percent in 1992, but around 20 percent-share of U.S. market is more or less equivalent to the cases of other East Asian countries.

two to three times in absolute terms: the growth rates are 191 percent for East Asia, 160 percent for Japan, 170 percent for NIEs³, 247 percent for ASEAN⁴, and 226 percent for China. For machinery trade as a whole and machinery parts and components trade, the corresponding figures are much higher, and even in the short period from 2001 to 2003, surprisingly, their drastic growth was observed (Tables 2a/b-5a/b).⁷ These figures imply that machinery trade should be and remain significant contributors to growth in intra-East Asian trade since the 1990s.

To what extent did machinery trade contribute to intra-regional export growth? Tables 2b-5b (2d-5d) also show the percentage of the contribution of machinery trade to the growth in intra-East Asian trade (East Asian trade). Roughly speaking, 66 percent (63 percent) of the growth in intra-East Asian trade (East Asian trade) during 13 years, 191 percent (150 percent), can be explained by machinery trade, and half (over one-third) by machinery parts and components. In other words, a large portion of the growth in intra-East Asian trade was induced by the expansion of machinery trade, mostly that of machinery parts and components, in East Asia. This can be regarded as a sort of “magnification effect” of machinery intermediates trade, which is referred to by Yi (2003). In East Asia, back-and-forth transactions in international production networks exist, and they are reflected in this magnification effect.

In the case of inter-regional trade in East Asia, similarly, machinery trade explain over 60 percent of the growth (Tables 2c-5c). The main factor of machinery trade contributed to the growth, however, is different from the case of intra-East Asian trade; around 60 percent of the growth in machinery trade (i.e., over 30 percent of the growth in all products) was induced by an expansion of machinery final goods, not that of machinery parts and components (Tables 2c-5c and Figure 8). It implies that machinery final goods produced in the international production networks in East Asia are sold to the United States, Europe, and so on, though the relative importance of these markets are rather decreasing as discussed above.

⁷ The growth rates in machinery trade as a whole and machinery parts and components trade are 322 percent and 452 percent for East Asia, 163 percent and 261 percent for Japan, 310 percent and 429 percent for NIEs³, 828 percent and 886 percent for ASEAN⁴, and 640 percent and 992 percent for China, respectively.

Figure 8

4. Intra-firm and arm's-length transactions: changing behavior of Japanese firms

The second question is how corporate firms combine two kinds of fragmentation in production/distribution networks. The intensive use of disintegration-type fragmentation or outsourcing arrangements is one of the salient phenomena in East Asia. Firms in East Asia have indigenous traditions of inter-firm linkages. We had an old legendary subcontracting system among Japanese firms, based on dualistic structure of large firms in the downstream and small/medium enterprises in the upstream. Taiwan had a tradition of peculiar horizontal subcontracting arrangements among machinery manufacturers. The Hong Kong Guangdong nexus developed innovative system of processing deal trade in textile and machinery industries. These traditions perhaps worked as prototypes of disintegration-type fragmentation in East Asia. The development of modulation technique was a technological backbone facilitating outsourcing arrangements.

The formal empirical analysis of intra-firm and arm's-length transactions is plagued by serious deficiency of statistical data. The analysis using the micro data of Japanese affiliates abroad, however, provides some limited information on the characteristics of production/distribution networks.

The analysis in this section is based on the micro data compiled by the Ministry of Economy, Trade, and Industry (METI), Government of Japan (the former name was the Ministry of International Trade and Industry (MITI)): *The 1993F/Y, 1996F/Y, 1999F/Y, and 2002F/Y Survey of Overseas Business Activities of Japanese Companies*. This database presents information on the performance of foreign affiliates of Japanese firms. In particular, the extensive surveys conducted every three years, which are used in this section, include detailed information on overseas business activities such as intra-firm and arm's length transactions. In this data set, foreign affiliates include both "affiliates abroad" with no less than 10 percent ownership by Japanese parent firms and "affiliates of affiliates abroad" with no less than 50 percent ownership by "affiliates abroad," except those in finance, insurance, or real estates. We must note that the effective return ratios are unfortunately as low as 60 percent since the survey is approved statistics.

Table 7 presents the number of Japanese affiliates located in East Asia and their performance in terms of total sales/purchases, by-destination sales/by-origin purchases ratios, and intra-firm transaction ratios in 1992, 1995, 1998, and 2001. As Table 7 displays, machinery industries (industry 290 to 320) hold over 30 percent and approximately 40 percent of the total number of Japanese affiliates in East Asia and their total sales/purchases in 2001, respectively. In particular, electric machinery (300) and transport equipment (310) sectors compose of a large portion of Japanese machinery affiliates in East Asia in terms of the number and their activities. To clarify features of their transactions, Tables 8-9 focus on intra-firm and arm's length transactions by Japanese electric machinery affiliates and Japanese transport equipment affiliates in East Asia, NIEs4, ASEAN4, and China, respectively, which are calculated based on Table 7 and corresponding tables to Japanese affiliates located in NIES4, ASEAN4, and China.⁸ In the tables, "local" means the country in which the affiliate concerned is located, "third countries" are countries other than Japan and "local," and "East Asia" indicates countries in East Asia other than Japan and "local."

Table 7

Table 8

Table 9

The nature of fragmentation and its changes over time can be observed particularly in the largest sector, electric machinery (300), and patterns of by-destination sales and by-origin purchases vividly present the development of international production/distribution networks. The most salient phenomenon is large and increasing share of sales/purchases with other East Asian countries, suggesting the extensiveness of networks and their development: shares of other East Asian countries increased from 18 percent (nine percent) in 1992 to 22 percent (20 percent) for sales and 15 percent (eight percent) in 1992 to 28 percent (20 percent) in the electric machinery sector

⁸ The corresponding tables to Japanese affiliates in NIES4, ASEAN4, and China are omitted from the paper, which are available upon request.

(machinery sectors as a whole). In addition, increasing shares of Japan in sales and decreasing shares of Japan in purchases indicate the expansion of back-and-forth cross-border production sharing as well as the development of local vendors. Decreasing trend of local sales ratios suggests switching weights from import-substituting-type industries to export-oriented, network-forming industries.

Ratios of intra-firm/arm's-length transactions conform to our two-dimensional fragmentation framework. Intra-firm transaction ratios for transactions with Japan, other East Asian countries, and local get smaller in this order. In other words, intra-firm transactions are large in transactions with Japan while arm's-length transactions are important in local transactions, and transactions with other East Asian countries are in the middle. This observation proves a close link between geographical proximity and disintegration-type fragmentation, indicating the formation of agglomeration of fragmented production blocks, as discussed in section 2.

The above-mentioned characteristics seem to be reflected most closely in the case of Japanese affiliates in ASEAN4 (Tables 8-9). In the case of Japanese affiliates in China, we must note that operations by Japanese firms in China were seriously started only recently (see values of sales and purchases in Table 8).⁹ Rapid increases in local purchases ratios from 16 percent in 1992 to 37 percent in 2001, eventually reaching up to the level of ASEAN4, suggest the formation of local vertical links in agglomeration in China.

On the other hand, declining trend in purchases from Japan, mostly intra-firm purchases, is clearly observed: shares of purchases from Japan (intra-firm purchases from Japan) in total purchases by Japanese electric machinery affiliates in China are 84 percent (78 percent) in 1992 and 38 percent (25 percent) in 2001. In China, purchases from Japan, particularly intra-firm purchases from Japan, seem to be significantly replaced by the local arm's length purchases according to the above-mentioned

⁹ The performance of Japanese electric machinery affiliates in China drastically enlarged from 70 billion JPY in 1992 to 1,298 billion JPY in 2001 for sales and from 47 billion JPY in 1992 to 919 billion JPY in 2001 for purchases. The number of affiliates also confirm the recent expansion of Japanese firms' operations in China: the number of Japanese electric machinery affiliates in China in the dataset is 30 (54) in 1992 and 281 (552) in 2001 in the electric machinery sector (machinery sectors as a whole), which accounts for around seven percent and 27 percent of Japanese electric machinery in East Asia, respectively.

development of agglomeration in the local market, and intra-firm purchases from other East Asian countries, probably mainly ASEAN countries. Although arm's length transaction ratios are large for transactions with other East Asian countries by Japanese electric machinery affiliates in ASEAN4, intra-firm transaction ratios are large by those in China. Such a difference in intra-firm transaction ratios with other East Asian countries may indicate proximity among ASEAN countries and remoteness of China from ASEAN4. Low intra-firm sales ratios in selling to local market perhaps reflect regulations on local distribution sector.

In contrast with the electric machinery sector, the transport equipment sector (310) is affected by import-substitution policies. Extremely high ratios of local sales in total sales reflect import-substitution policies applied by most of the East Asian countries, though the ratios have a decreasing trend.¹⁰

5. Global networks of Japanese firms: the Baldwin-Kimura approach

The last section tried to capture the activities of Japanese firms in East Asia by analyzing patterns of by-destination sales/by-origin purchases. These statistical figures, however, do not directly indicate the magnitude of Japanese firms' activities in both exporting from Japan and producing in East Asia; since intermediate inputs embodied in traded commodities may be counted multiple times, the amount of gross sales does not necessarily reflect the importance of each transaction. In addition, those figures do not directly imply who is trading with whom, considering firm nationality. For instance, arm's length transactions in local market by Japanese affiliates in East Asia include not only transactions with other nationality firms but also those with other Japanese affiliates in the local market. Thus, this section introduces a concept of value added contents and attempts to quantify the importance of each channel of transactions, reflecting firm nationality.

To quantify the whole Japanese firms' activities in different locations and embodied value added contents in international transactions, this section employs the

¹⁰ Ando (2005) demonstrates that even in the transportation equipment sector, in which one-way trade is still the main pattern of trade in the whole sector largely due to import substitution policy, vigorous transactions of parts and components across borders were observed in 2000 while they were seldom found at the beginning of the 1990s.

firm nationality approach, which was first proposed by Baldwin and Kimura (1998) and Kimura and Baldwin (1998) in a two-country setting, was extended to a three-country setting by Kimura (1998), and was recently applied to the Japanese firms' activities in 2000 by Ando and Kimura (2005). In this section, the previous model in a three-country setting is slightly extended by incorporating intra-firm and arm's length transactions estimated in section 4.

The firm nationality approach in a three-country setting thinks of three geographical territories, i.e., Japan, Asia, and the rest of the world (ROW) as well as three nationals, i.e., Japanese, Asians, and foreigners (the national of ROW).¹¹ "Japanese" consist of Japanese-owned firms located in Japan, households and governments located in Japan, and foreign affiliates of Japanese firms (FAJFs) located in Asia and ROW.¹² Asians and foreigners are defined in the symmetric way. Three nationals reside in three different locations, and thus 9 blocks are drawn as in Figure 9. Although transactions within a block and between blocks are, conceptually, illustrated as 81 (9 times 9) arrows in total, we can fill out 14 arrows of transactions because only statistical data from the Japanese side are readily available.

Figure 9

The figures shown for 14 arrows in Figure 9 stand for the estimated Japanese value added contents of each transaction embodied at the starting point of the corresponding arrow in 2001, based on the estimates in Table A.2 in the Appendix. The figures in parenthesis in Figure 9 are value added embodied in arm's length transactions for the corresponding arrows. The detailed explanation of estimation method is also given in Table A.2.

Although these figures are only rough estimates with a number of reservations on the data set, the value added account provides useful insights on the activities of Japanese multinational enterprises (MNEs). Major findings are the following three: first, the activities of FAJFs in Asia become significant, and the formation of

¹¹ Asia stands for Asian countries east of Pakistan in this section.

¹² Note that "Japanese" in this definition is different from those on the residency basis or those in the sense of factor holders; we treat FAJF as controlled by Japanese and count the whole activities of FAJF as activities by Japanese.

agglomeration is observed. 5.7 trillion yen of Japanese value added contents are exported by Japanese in Japan to FAJFs in Asia, while Japanese in Asia earn 8.1 trillion yen of value added. 3.3 trillion yen of value added contents earned by FAJFs are embodied in transactions among FAJFs in Asia, in which arm's-length transactions have large shares, suggesting active vertical transactions in the agglomeration by FAJFs.

Second, there are three major channels when Japanese intend to sell their products to Asians in Asia, i.e., “to produce in Japan and export directly”, “to produce in Japan and distribute through FAJFs in Asia”, and “to produce in Japan and distribute through FAJFs in Asia”. The channel, “to produce in Japan and export directly”, accounts for 72 percent of total value added contents embodied in sales of Japanese to Asians in Asia, “to produce in Japan and distribute through FAJFs in Asia” 11 percent (seven percent through intra-firms and four percent through arm's length), and “to produce in Asia and sell locally” 15 percent.¹³ We can guess that these products certainly include a large portion of machinery parts and components, suggesting active arm's-length/across-firm-nationality transactions occur in production/distribution networks.

Third, FAJFs in Asia do not directly sell much to the ROW including the US and EU markets. This of course does not necessarily mean that Japanese value added contents are barely exported to the US or EU. Rather, machinery parts and components supplied by Japanese companies may perhaps be crucial inputs when firms with different nationalities intend to export to the US and EU markets. This again suggests the existence of vertical production sharing among firms with different nationalities.

6. Concluding remarks

This paper applies the two-dimensional fragmentation framework to empirically examine the structure and characteristics of international

¹³ Total value added contents embodied in sales of Japanese to Asians in Asia here are estimated as the sum of those through the following channels: “to produce in Japan and export directly”, “to produce in Japan and distribute through FAJFs in Asia”, “to produce in Japan and distribute through FAJFs in ROW”, “to produce in Japan and distribute through FAJFs in Asia”, and “to produce in ROW and export to Asia”.

production/distribution networks. The analysis on international trade data, particularly trade in machineries and machinery parts and components, verifies the importance of international production/distribution networks in the East Asian economies, and enhancing relative importance of intra-East Asian markets to other markets outside of the region including the U.S market for East Asian exports. The investigation of the data set of affiliates of Japanese firms in East Asia suggests the microstructure of vertical production chains effectively combining intra-firm and arm's-length transactions. The application of the Baldwin-Kimura approach presents the overall picture of worldwide production/distribution networks in the case of Japanese firms, showing a sharp contrast between operations in East Asia and those in the rest of the world. The authors believe that the paper successfully reconfirms the distinctive characteristics of international production distribution networks; i.e., their significance, extensiveness, and sophistication.

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Figure 1 Typical maquila operation by the US MNEs: an illustration

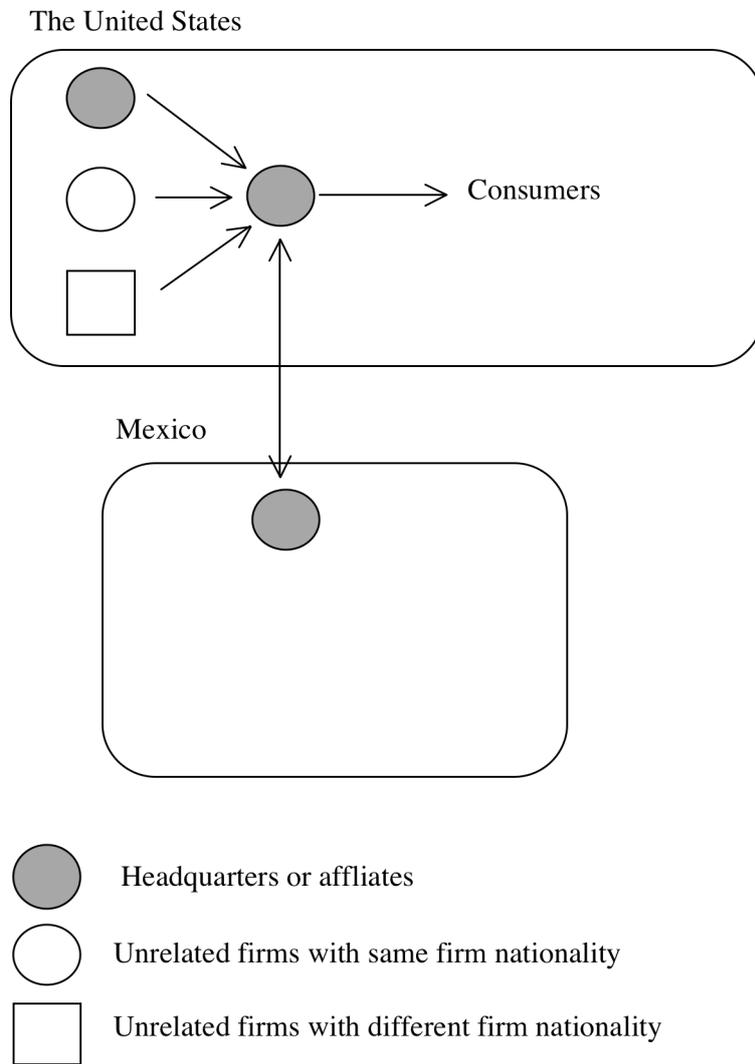


Figure 2 Typical East Asian operation by Japanese MNEs: an illustration

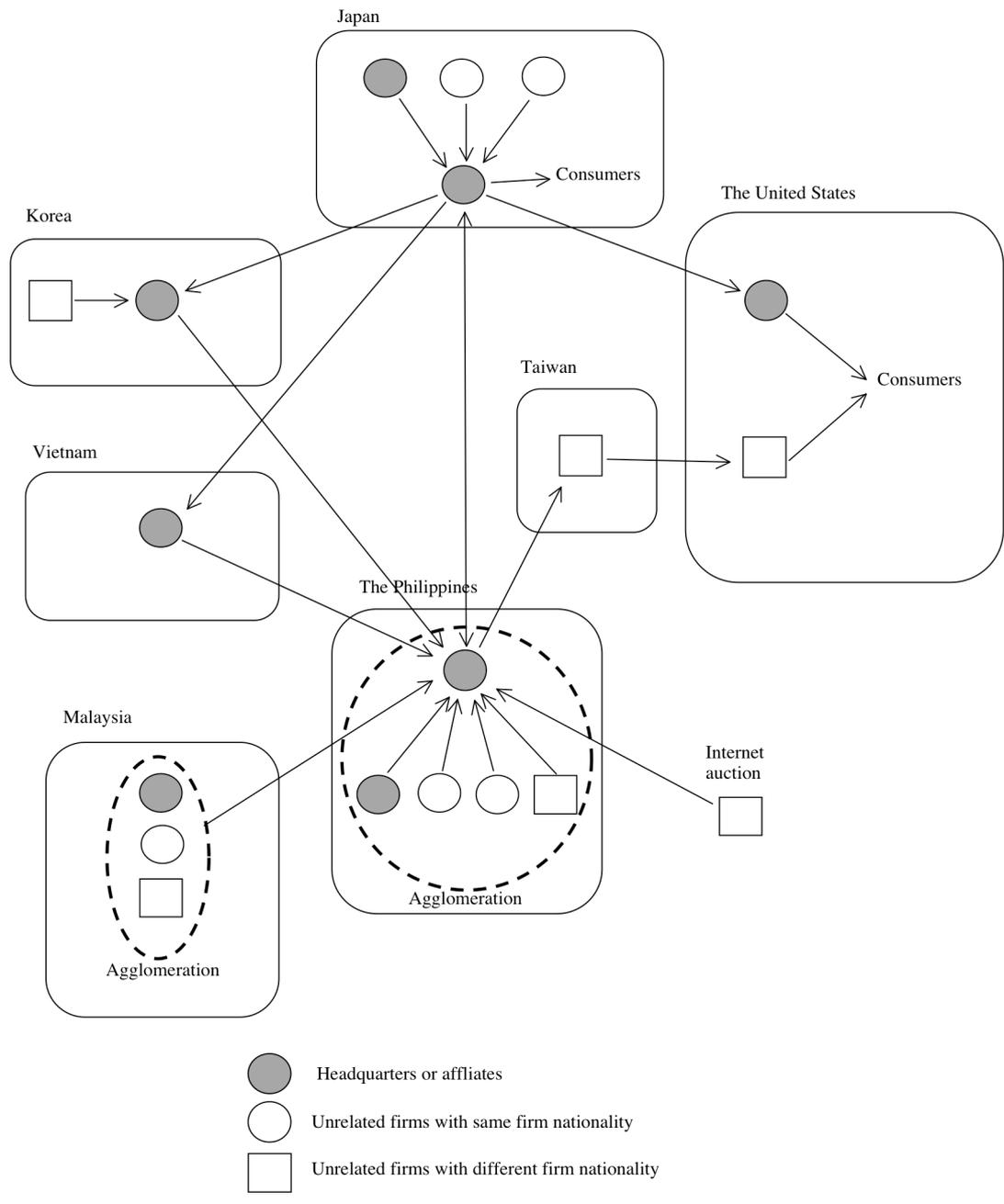


Figure 3 Fragmentation in a two-dimensional space

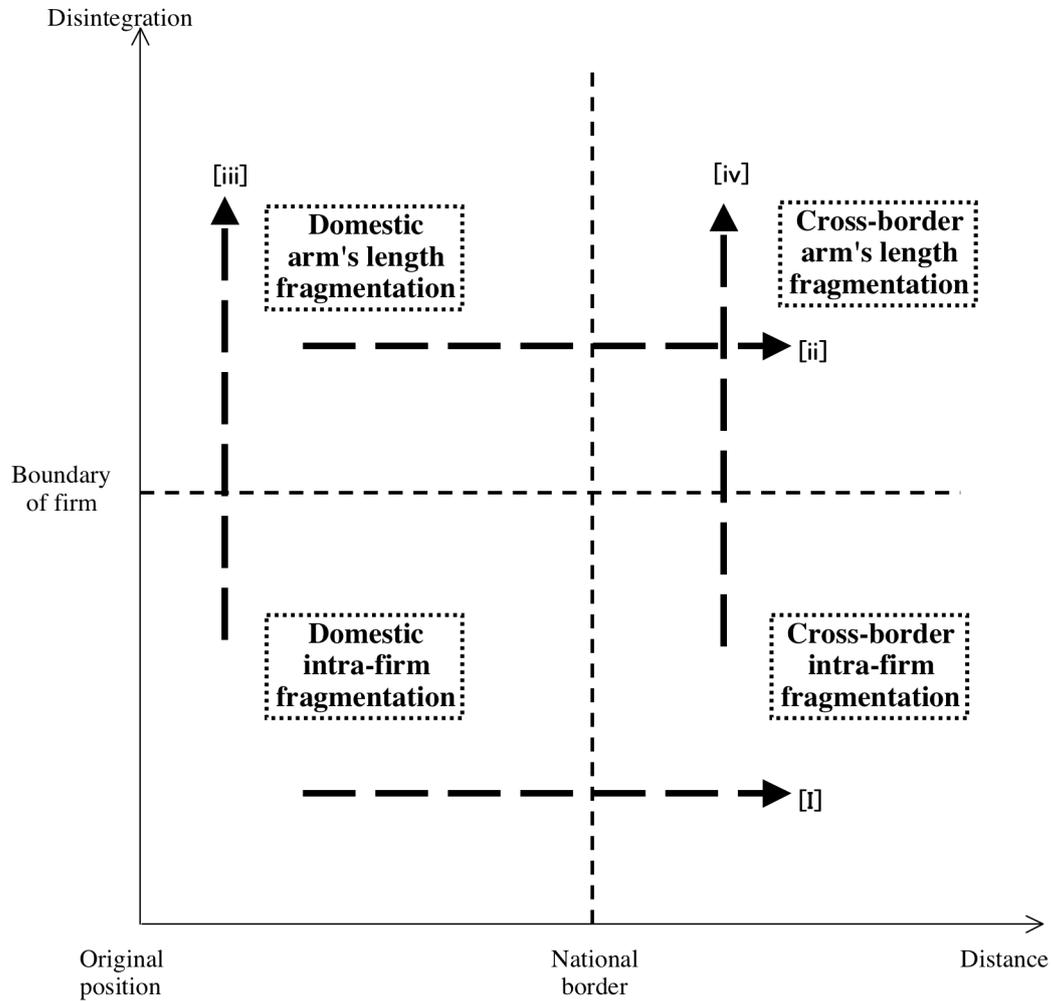


Table 1 Tradeoffs in two-dimensional fragmentation

	Service link cost connecting production block	Production cost per se in production blocks
Fragmentation along the distance axis	Cost due to geographical distance Elements (examples): transportation, telecommunications, inefficiency in distribution, trade impediments, coordination cost	Cost reduction from location advantages Elements (examples): wage level, access to resources, infrastructure service inputs such as electricity, water, and industrial estates, technological capability
Fragmentation along the disintegration axis	Transaction cost due to losing controllability Elements (examples): Information gathering cost on potential business partners, monitoring cost, risks on the stability of contracts, immature dispute settlement mechanism, other deficiency in legal system and economic institutions	Cost reduction from (dis)internalization Elements (examples): availability of various types of potential business partners including foreign and indigenous firms, development of supporting industry, institutional capacity for various types of contracts, degree of incomplete information

Figure 4 Two kinds of service link cost

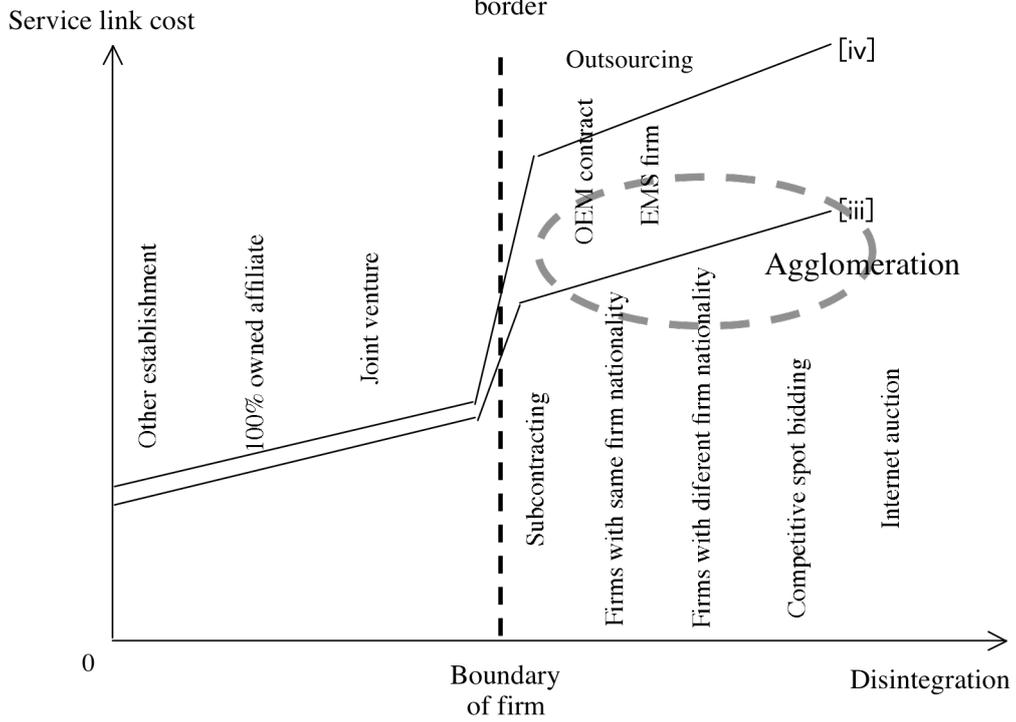
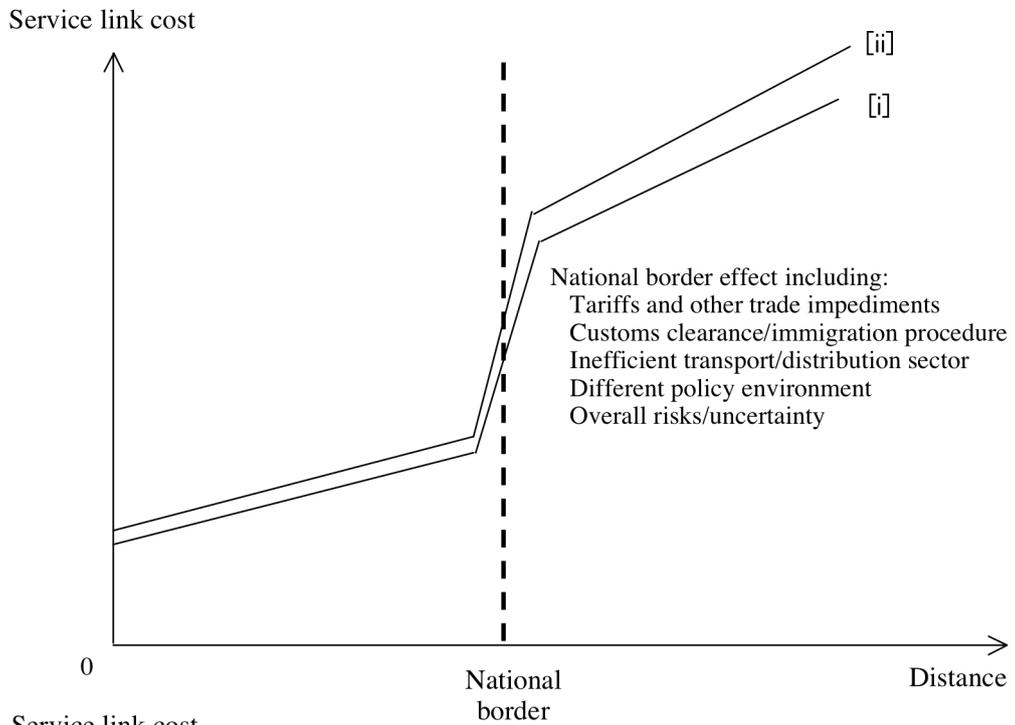


Figure 5 Multilayered fragmentation in East Asia: an illustration

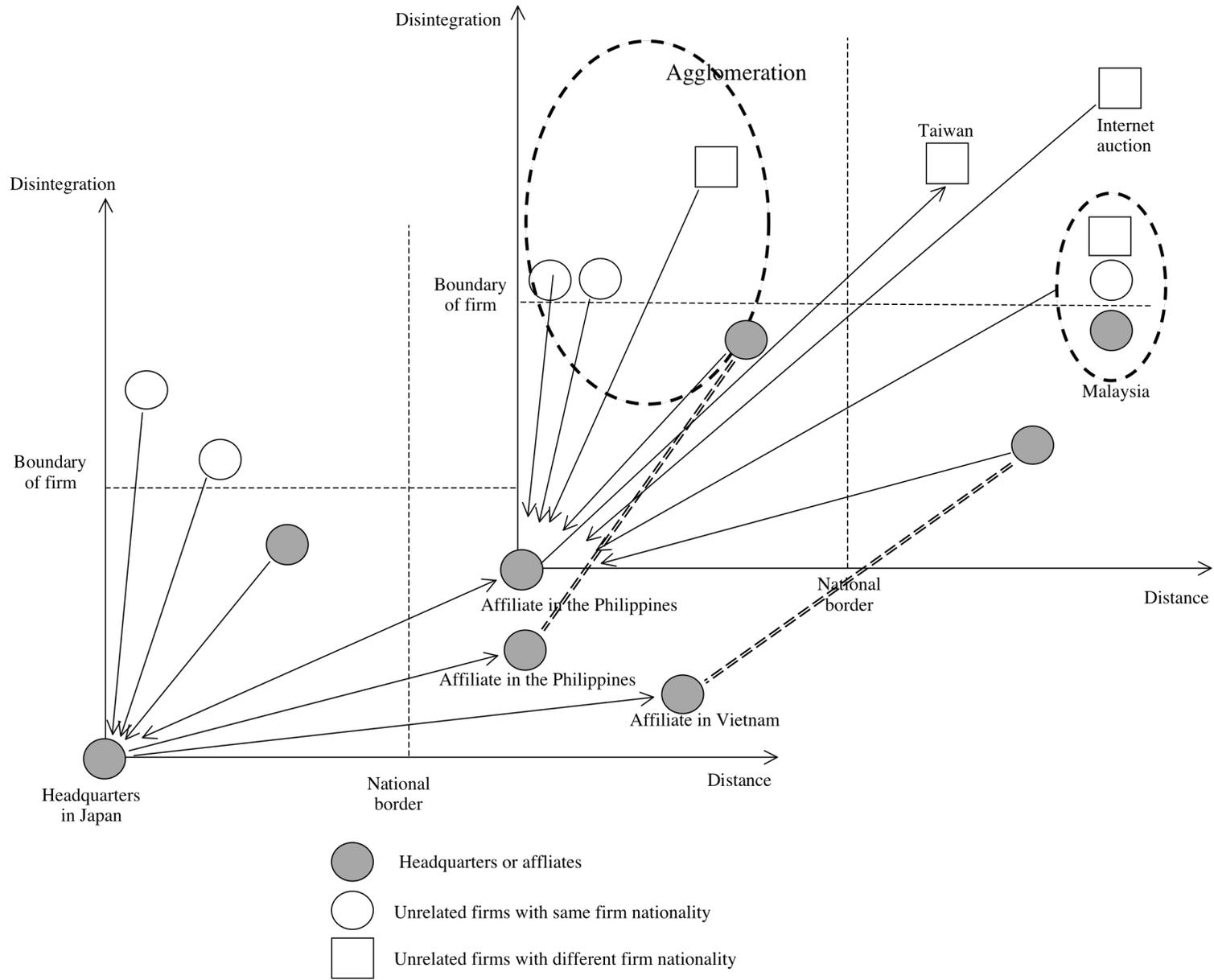
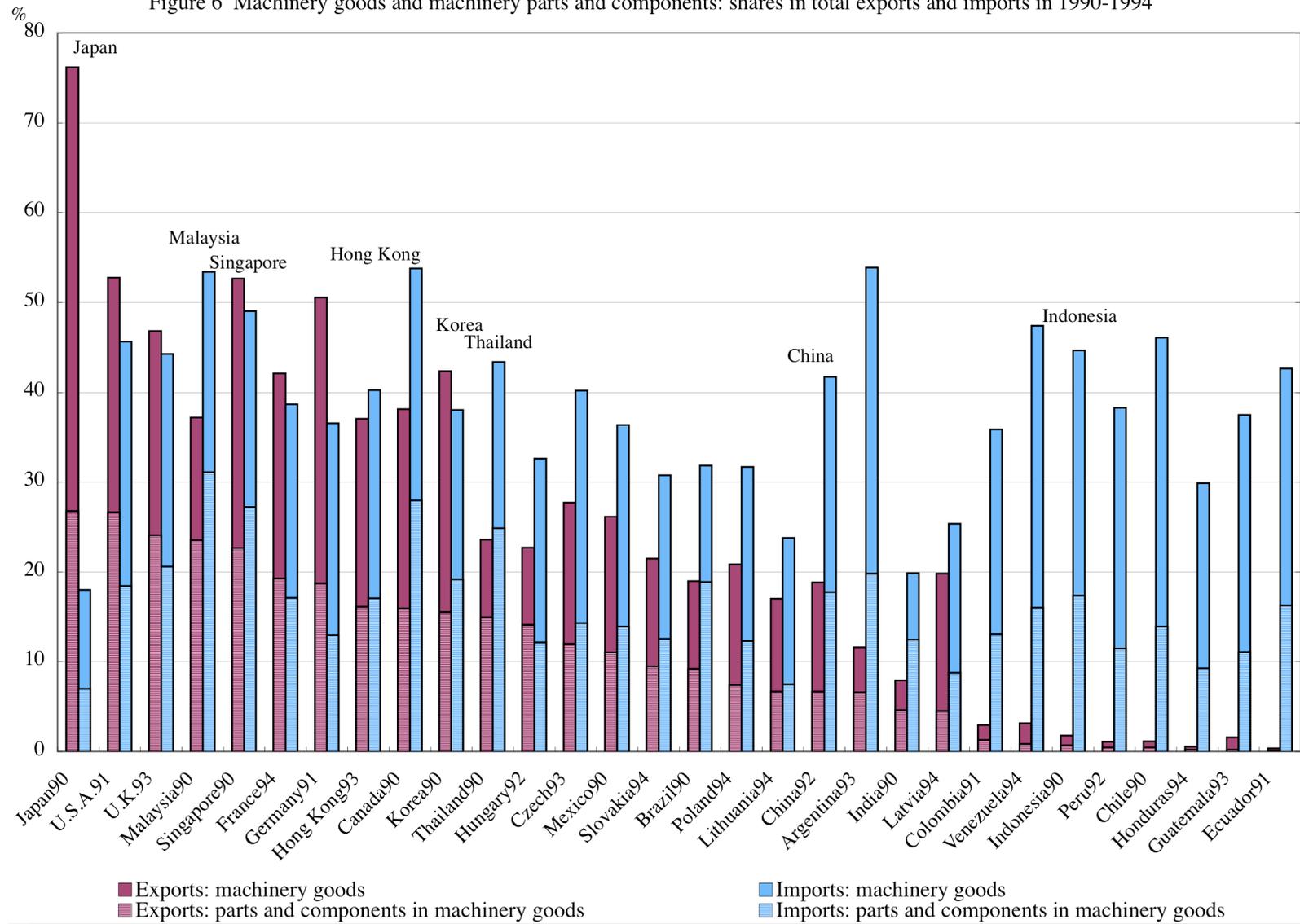


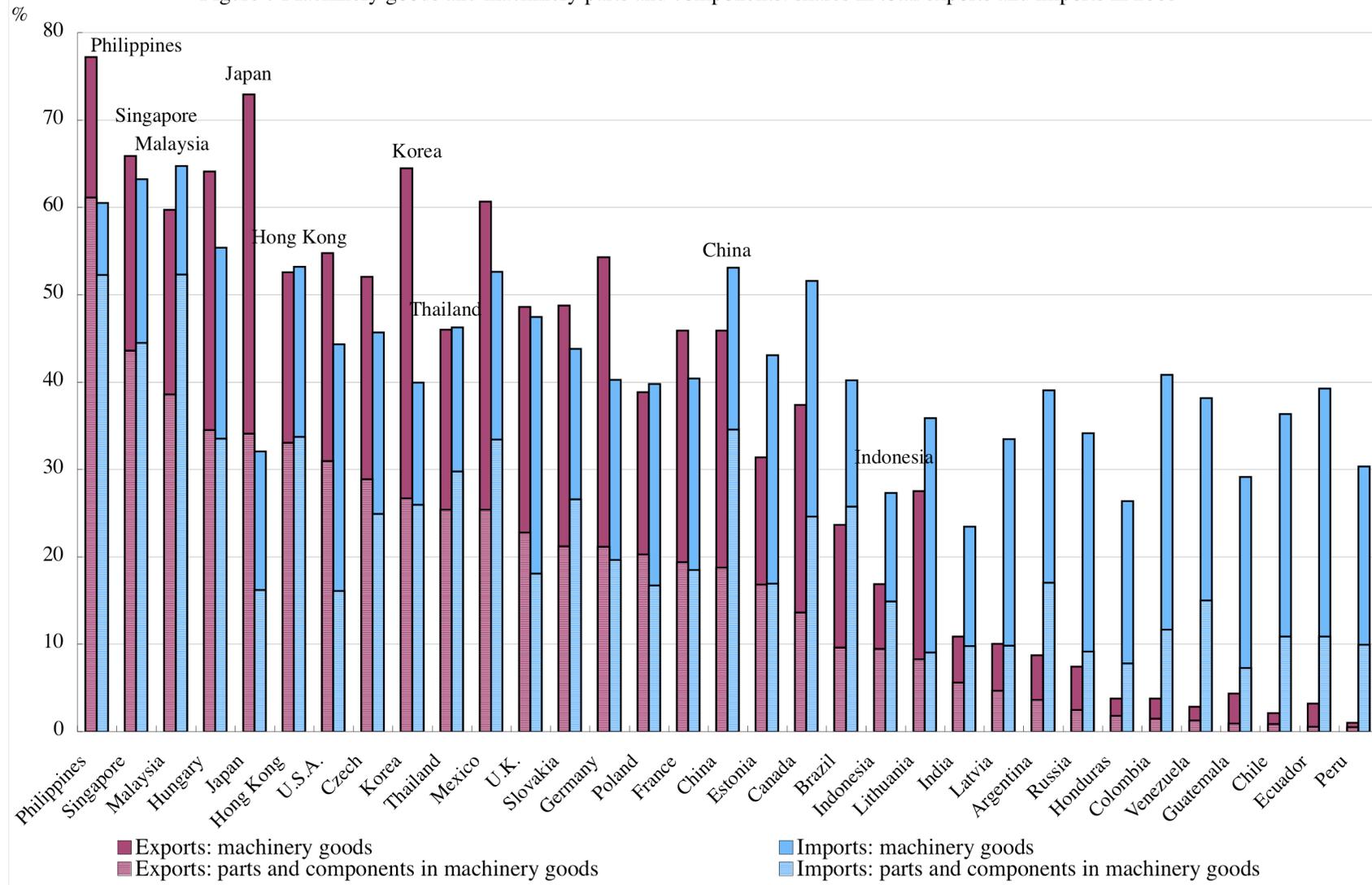
Figure 6 Machinery goods and machinery parts and components: shares in total exports and imports in 1990-1994



Data source: Ando (2005).

Note: data is of 1990 or close to 1990. For instance, Japan90 and U.S.A.91 indicate that data is of 1990 for Japan and 1991 for U.S.A.

Figure 7 Machinery goods and machinery parts and components: shares in total exports and imports in 2003



Data source: Authors' calculation, based on UN COMTRADE.

Table 2a Development of intra-regional exports in East Asia

	(Millions US\$, %)					
	1990		2001		2003	
	Value	Share	Value	Share	Value	Share
Machinery goods: parts and components						
Intra-East Asia	54,336	39.6	205,636	51.4	300,137	57.5
Others	82,915	60.4	194,805	48.6	221,637	42.5
(U.S.)	(39,624)	(28.9)	(81,426)	(20.3)	(82,543)	(15.8)
Total	137,251	100.0	400,442	100.0	521,774	100.0
Machinery goods: final goods						
Intra-East Asia	50,932	23.2	99,364	26.1	144,368	28.8
Others	168,597	76.8	281,492	73.9	356,732	71.2
(U.S.)	(70,183)	(32.0)	(130,088)	(34.2)	(143,634)	(28.7)
Total	219,529	100.0	380,856	100.0	501,100	100.0
Machinery goods: total						
Intra-East Asia	105,268	29.5	305,001	39.0	444,505	43.5
Others	251,512	70.5	476,297	61.0	578,369	56.5
(U.S.)	(109,807)	(30.8)	(211,513)	(27.1)	(226,177)	(22.1)
Total	356,780	100.0	781,297	100.0	1,022,875	100.0
All products						
Intra-East Asia	270,465	38.5	579,108	42.1	786,197	44.7
Others	432,736	61.5	795,192	57.9	973,074	55.3
(U.S.)	(174,978)	(24.9)	(332,883)	(24.2)	(355,643)	(20.2)
Total	703,201	100.0	1,374,300	100.0	1,759,271	100.0

Data source: authors' calculation, based on UN COMTRADE

Note: "East Asia" here includes China, ASEAN4, NIES3, and Japan. Due to lack of data available from UN COMEXTRADE, (i) Taiwan is not included in East Asia, (ii) data for China in 1992 and Hong Kong in 1993 are used in calculating intra-East Asian exports in 1990, (iii) data for the Philippines are not included in calculating intra-East Asian exports in 1990.

Table 2b Factors of growth in intra-East Asian exports (%)

(i) Growth in intra-East Asian exports (1990-2003)	
All products	190.7
Machinery goods (total)	322.3
- Machinery final goods	183.5
- Machinery parts and components	452.4
(ii) Contribution to growth in intra-East Asian exports	
Machinery goods (total)	65.8
- Machinery final goods	18.1 (28)
- Machinery parts and components	47.7 (72)

Table 2c Factors of growth in inter-regional exports (%)

(i) Growth in inter-regional exports (1990-2003)	
All products	124.9
Machinery goods (total)	130.0
- Machinery final goods	111.6
- Machinery parts and components	167.3
(ii) Contribution to growth in inter-regional exports	
Machinery goods (total)	60.5
- Machinery final goods	34.8 (58)
- Machinery parts and components	25.7 (42)

Table 2d Factors of growth in East Asian exports (%)

(i) Growth in East Asian exports (1990-2003)	
All products	150.2
Machinery goods (total)	186.7
- Machinery final goods	128.3
- Machinery parts and components	280.2
(ii) Contribution to growth in East Asian exports	
Machinery goods (total)	63.1
- Machinery final goods	26.7 (42)
- Machinery parts and components	36.4 (58)

Table 3a Development of intra-regional exports in Japan

	(Millions US\$, %)					
	1990		2001		2003	
	Value	Share	Value	Share	Value	Share
Machinery goods: parts and components						
Intra-East Asia	21,217	27.5	55,797	40.1	76,645	47.6
Others (U.S.)	55,921 (26,401)	72.5 (34.2)	83,205 (39,191)	59.9 (28.2)	84,232 (35,694)	52.4 (22.2)
Total	77,138	100.0	139,002	100.0	160,877	100.0
Machinery goods: final goods						
Intra-East Asia	22,861	16.2	27,649	17.6	39,330	21.5
Others (U.S.)	118,560 (49,971)	83.8 (35.3)	129,165 (60,832)	82.4 (38.8)	143,856 (59,307)	78.5 (32.4)
Total	141,421	100.0	156,814	100.0	183,186	100.0
Machinery goods: total						
Intra-East Asia	44,078	20.2	83,446	28.2	115,974	33.7
Others (U.S.)	174,480 (76,373)	79.8 (34.9)	212,370 (100,023)	71.8 (33.8)	228,088 (95,001)	66.3 (27.6)
Total	218,559	100.0	295,815	100.0	344,062	100.0
All products						
Intra-East Asia	69,431	24.2	131,772	32.7	180,469	38.2
Others (U.S.)	217,517 (90,944)	75.8 (31.7)	271,591 (122,549)	67.3 (30.4)	291,527 (117,539)	61.8 (24.9)
Total	286,947	100.0	403,364	100.0	471,996	100.0

Data source: authors' calculation, based on UN COMTRADE.

Note: "Intra-East Asia" here includes China, ASEAN4, and NIES3. Due to lack of data available from UN COMTRADE, Taiwan is not included in East Asia.

Table 3b Factors of growth in Japanese intra-East Asian export (%)

(i) Growth in Japanese intra-East Asian exports (1990-2003)	
All products	159.9
Machinery goods (total)	163.1
- Machinery final goods	72.0
- Machinery parts and components	261.2
(ii) Contribution to growth in Japanese intra-East Asian exports	
Machinery goods (total)	64.7
- Machinery final goods	14.8 (23)
- Machinery parts and components	49.9 (77)

Table 3c Factors of growth in Japanese inter-regional exports (%)

(i) Growth in Japanese inter-regional exports (1990-2003)	
All products	34.0
Machinery goods (total)	30.7
- Machinery final goods	21.3
- Machinery parts and components	50.6
(ii) Contribution to growth in Japanese inter-regional exports	
Machinery goods (total)	72.4
- Machinery final goods	34.2 (47)
- Machinery parts and components	38.3 (53)

Table 3d Factors of growth in Japanese exports (%)

(i) Growth in Japanese exports (1990-2003)	
All products	64.5
Machinery goods (total)	57.4
- Machinery final goods	29.5
- Machinery parts and components	108.6
(ii) Contribution to growth in East Asian exports	
Machinery goods (total)	67.8
- Machinery final goods	22.6 (33)
- Machinery parts and components	45.3 (67)

Table 4a Development of intra-regional exports in NIEs3

	1990		2001		2003	
	Value	Share	Value	Share	Value	Share
Machinery goods: parts and components						
Intra-East Asia	23,518	53.6	84,623	59.0	124,336	65.4
Others	20,357	46.4	58,739	41.0	65,738	34.6
(U.S.)	(9,600)	(21.9)	(20,881)	(14.6)	(21,247)	(11.2)
Total	43,875	100.0	143,363	100.0	190,074	100.0
Machinery goods: final goods						
Intra-East Asia	18,499	30.1	34,740	28.8	48,111	32.1
Others	43,033	69.9	86,046	71.2	101,913	67.9
(U.S.)	(17,336)	(28.2)	(32,909)	(27.2)	(36,329)	(24.2)
Total	61,532	100.0	120,786	100.0	150,024	100.0
Machinery goods: total						
Intra-East Asia	42,017	39.9	119,363	45.2	172,447	50.7
Others	63,390	60.1	144,785	54.8	167,651	49.3
(U.S.)	(26,936)	(25.6)	(53,790)	(20.4)	(57,576)	(16.9)
Total	105,407	100.0	264,148	100.0	340,098	100.0
All products						
Intra-East Asia	104,639	41.3	213,351	46.1	282,712	49.9
Others	148,478	58.7	249,903	53.9	284,008	50.1
(U.S.)	(61,841)	(24.4)	(92,466)	(20.0)	(96,642)	(17.1)
Total	253,116	100.0	463,254	100.0	566,720	100.0

Data source: authors' calculation, based on UN COMTRADE.

Note: "Intra-East Asia" here includes China, ASEAN4, and Japan. Due to lack of data available from UN COMTRADE, (i) Taiwan is not included in East Asia, and (ii) data for Hong Kong in 1993 are used in calculating intra-East Asian exports in 1990.

Table 4b Factors of growth in NIEs' intra-East Asian export (%)

(i) Growth in NIEs' intra-East Asian exports (1990-2003)	
All products	170.2
Machinery goods (total)	310.4
- Machinery final goods	160.1
- Machinery parts and components	428.7
(ii) Contribution to growth in NIEs' intra-East Asian exports	
Machinery goods (total)	73.2
- Machinery final goods	16.6 (23)
- Machinery parts and components	56.6 (77)

Table 4c Factors of growth in NIEs' inter-regional exports (%)

(i) Growth in NIEs' inter-regional exports (1990-2003)	
All products	91.3
Machinery goods (total)	164.5
- Machinery final goods	136.8
- Machinery parts and components	222.9
(ii) Contribution to growth in NIEs' inter-regional exports	
Machinery goods (total)	76.9
- Machinery final goods	43.4 (56)
- Machinery parts and components	33.5 (44)

Table 4d Factors of growth in NIEs' exports (%)

(i) Growth in NIE's exports (1990-2003)	
All products	123.9
Machinery goods (total)	222.7
- Machinery final goods	143.8
- Machinery parts and components	333.2
(ii) Contribution to growth in NIEs' exports	
Machinery goods (total)	74.8
- Machinery final goods	28.2 (38)
- Machinery parts and components	46.6 (62)

Table 5a Development of intra-regional exports in ASEAN4

	1990		2001		2003	
	Value	Share	Value	Share	Value	Share
(Millions US\$, %)						
Machinery goods: parts and components						
Intra-East Asia	5,383	51.0	40,842	54.7	53,087	59.9
Others	5,170	49.0	33,851	45.3	35,583	40.1
(U.S.)	(3,162)	(30.0)	(14,335)	(19.2)	(13,102)	(14.8)
Total	10,553	100.0	74,693	100.0	88,670	100.0
Machinery goods: final goods						
Intra-East Asia	2,187	34.7	15,005	34.2	17,129	34.9
Others	4,107	65.3	28,912	65.8	31,883	65.1
(U.S.)	(2,004)	(31.8)	(12,776)	(29.1)	(15,157)	(30.9)
Total	6,293	100.0	43,918	100.0	49,012	100.0
Machinery goods: total						
Intra-East Asia	7,570	44.9	55,848	47.1	70,217	51.0
Others	9,276	55.1	62,763	52.9	67,466	49.0
(U.S.)	(5,166)	(30.7)	(27,110)	(22.9)	(28,259)	(20.5)
Total	16,846	100.0	118,611	100.0	137,682	100.0
All products						
Intra-East Asia	40,548	51.9	114,181	47.3	140,831	49.9
Others	37,649	48.1	127,404	52.7	141,497	50.1
(U.S.)	(13,594)	(17.4)	(47,819)	(19.8)	(48,835)	(17.3)
Total	78,197	100.0	241,584	100.0	282,327	100.0

Data source: authors' calculation, based on UN COMTRADE.

Note: "Intra-East Asia" here includes China, NIES3, and Japan. Due to lack of data available from UN COMTRADE, (i) Taiwan is not included in East Asia, and (ii) data for the Philippines are not included in calculating intra-East Asian trade in 1990.

Table 5b Factors of growth in ASEAN4's intra-East Asian exports (%)

(i) Growth in ASEAN4's intra-East Asian exports (1990-2003)	
All products	247.3
Machinery goods (total)	827.6
- Machinery final goods	683.4
- Machinery parts and components	886.1
(ii) Contribution to growth in ASEAN4's intra-East Asian exports	
Machinery goods (total)	62.5
- Machinery final goods	14.9 (24)
- Machinery parts and components	47.6 (76)

Table 5c Factors of growth in ASEAN4's inter-regional exports (%)

(i) Growth in ASEAN4's inter-regional exports (1990-2003)	
All products	275.8
Machinery goods (total)	627.3
- Machinery final goods	676.4
- Machinery parts and components	588.3
(ii) Contribution to growth in ASEAN4's inter-regional exports	
Machinery goods (total)	56.0
- Machinery final goods	26.7 (48)
- Machinery parts and components	29.3 (52)

Table 5d Factors of growth in ASEAN4's exports (%)

(i) Growth in ASEAN4's exports (1990-2003)	
All products	261.0
Machinery goods (total)	717.3
- Machinery final goods	678.8
- Machinery parts and components	740.2
(ii) Contribution to growth in ASEAN4's exports	
Machinery goods (total)	59.2
- Machinery final goods	20.9 (35)
- Machinery parts and components	38.3 (65)

Table 6a Development of intra-regional exports in China

	1990		2001		2003	
	Value	Share	Value	Share	Value	Share
Machinery goods: parts and components						
Intra-East Asia	4,218	74.2	24,374	56.2	46,069	56.1
Others (U.S.)	1,468 (460)	25.8 (8.1)	19,010 (7,018)	43.8 (16.2)	36,084 (12,500)	43.9 (15.2)
Total	5,685	100.0	43,384	100.0	82,154	100.0
Machinery goods: final goods						
Intra-East Asia	7,385	71.8	21,970	37.0	39,798	33.5
Others (U.S.)	2,898 (872)	28.2 (8.5)	37,369 (23,572)	63.0 (39.7)	79,080 (32,841)	66.5 (27.6)
Total	10,283	100.0	59,339	100.0	118,878	100.0
Machinery goods: total						
Intra-East Asia	11,603	72.7	46,344	45.1	85,868	42.7
Others (U.S.)	4,366 (1,332)	27.3 (8.3)	56,379 (30,590)	54.9 (29.8)	115,164 (45,340)	57.3 (22.6)
Total	15,968	100.0	102,723	100.0	201,032	100.0
All products						
Intra-East Asia	55,848	65.7	119,804	45.0	182,185	41.6
Others (U.S.)	29,092 (8,599)	34.3 (10.1)	146,294 (70,050)	55.0 (26.3)	256,043 (92,626)	58.4 (21.1)
Total	84,940	100.0	266,098	100.0	438,228	100.0

Data source: authors' calculation, based on UN COMTRADE.

Note: "Intra-East Asia" here includes ASEAN4, NIES3, and Japan. Due to lack of data available from UN COMTRADE, (i) Taiwan is not included in East Asia, and (ii) data for China in 1992 are used in calculating intra-East Asian trade in 1990.

Table 6b Factors of growth in Chinese intra-East Asian export (%)

(i) Growth in Chinese intra-East Asian exports (1990-2003)	
All products	226.2
Machinery goods (total)	640.1
- Machinery final goods	438.9
- Machinery parts and components	992.3
(ii) Contribution to growth in Chinese intra-East Asian exports	
Machinery goods (total)	58.8
- Machinery final goods	25.7 (44)
- Machinery parts and components	33.1 (56)

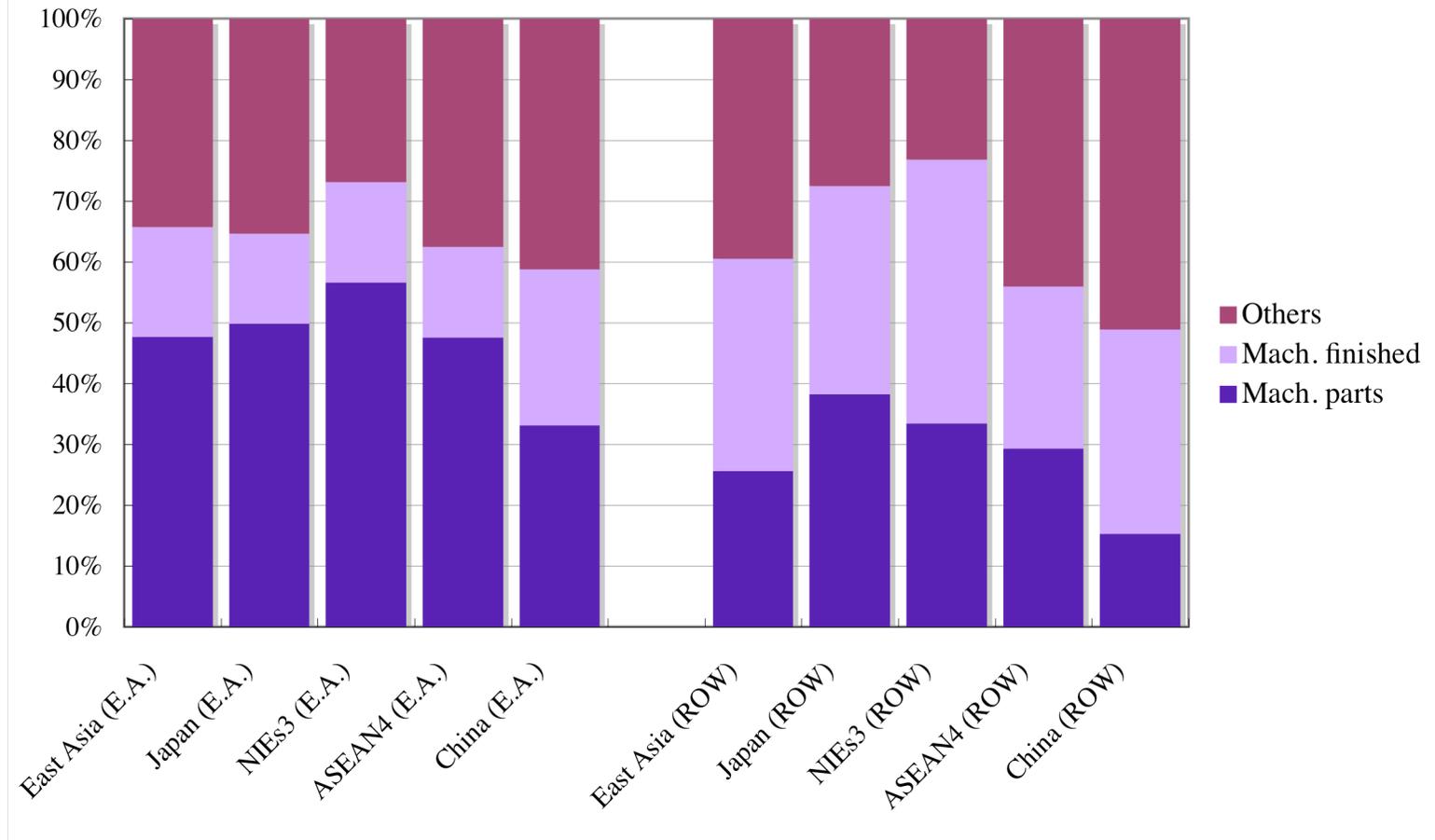
Table 6c Factors of growth in Chinese inter-regional exports (%)

(i) Growth in Chinese inter-regional exports (1990-2003)	
All products	780.1
Machinery goods (total)	2537.9
- Machinery final goods	2628.8
- Machinery parts and components	2358.4
(ii) Contribution to growth in Chinese inter-regional exports	
Machinery goods (total)	48.8
- Machinery final goods	33.6 (69)
- Machinery parts and components	15.3 (31)

Table 6d Factors of growth in Chinese exports (%)

(i) Growth in Chinese exports (1990-2003)	
All products	415.9
Machinery goods (total)	1158.9
- Machinery final goods	1056.1
- Machinery parts and components	1345.0
(ii) Contribution to growth in Chinese exports	
Machinery goods (total)	52.4
- Machinery final goods	30.7 (59)
- Machinery parts and components	21.6 (41)

Figure 8 Contribution to growth in intra- and inter-regional exports in East Asia: 1990-2003



Data source: Tables 2b/c-6b/c.

Note: "E.A." and "ROW" in the figure indicate intra-regional exports and inter-regional exports, respectively.

Table 7 Sales and purchases by Japanese affiliates in East Asia

Year	Industry	Number of affiliates	%	Total sales (millions JPY)	%	By-destination sales ratio (%)						Intra-firm transaction ratio (%)					
						Japan		Local		Third countries		Japan		Local		Third countries	
										East Asia	North America	Europe					East Asia
(a) Sales																	
1992	Manufacturing	1,463	56.3	7,886,679	50.7	15.8	66.0	18.2	10.0	3.4	1.8	84.2	6.3	42.9	44.6	62.6	47.7
	Machinery	715	27.5	5,202,107	33.4	16.8	66.2	17.0	9.4	4.0	1.8	90.5	7.8	57.7	53.9	76.6	65.0
	290	91	3.5	216,235	1.4	23.6	53.0	23.4	11.3	2.1	9.8	96.7	3.0	71.2	55.6	54.3	93.9
	300	416	16.0	2,872,411	18.5	27.2	45.7	27.1	17.7	4.9	2.1	90.0	8.0	56.2	53.5	82.6	58.0
	310	171	6.6	1,998,597	12.8	1.7	92.6	5.7	0.8	3.1	0.4	73.9	7.2	60.2	57.9	71.2	28.3
	320	37	1.4	114,864	0.7	51.8	36.9	11.3	1.6	4.5	3.3	96.5	32.4	46.6	77.9	51.1	50.8
	Total	2,597	100.0	15,556,096	100.0	21.8	59.4	18.8	9.3	2.4	1.2	64.1	4.7	28.9	33.1	53.5	44.8
1995	Manufacturing	2,966	64.5	12,299,770	50.0	18.8	58.4	22.8	13.3	3.6	1.8	83.2	15.8	45.4	49.1	57.0	60.7
	Machinery	1,428	31.0	9,080,009	36.9	20.8	56.6	22.6	12.8	4.0	1.9	90.6	19.9	55.4	60.2	64.8	71.5
	290	234	5.1	540,926	2.2	28.5	48.5	23.1	13.9	0.7	5.4	97.6	1.5	68.8	66.5	71.4	98.7
	300	755	16.4	5,107,148	20.8	28.7	38.0	33.2	19.6	5.6	2.2	88.9	9.0	52.6	59.5	56.7	58.4
	310	339	7.4	3,094,685	12.6	2.2	92.8	5.0	0.8	2.3	0.8	85.1	27.3	65.4	30.3	97.2	94.5
	320	100	2.2	337,250	1.4	51.2	27.7	21.1	15.9	1.9	2.2	98.9	66.6	74.7	76.6	69.3	75.5
	Total	4,600	100.0	24,578,689	100.0	17.8	54.7	27.5	13.5	2.5	1.4	67.6	10.4	24.3	31.2	49.1	58.3
1998	Manufacturing	3,835	61.7	12,324,572	53.0	25.4	49.2	25.4	16.9	4.5	2.7	73.1	7.6	45.9	47.2	48.3	40.7
	Machinery	1,809	29.1	8,485,148	36.5	44.1	38.6	17.3	15.4	1.1	0.4	80.6	15.6	48.7	47.5	50.8	63.7
	290	315	5.1	688,971	3.0	40.7	32.4	27.0	14.8	5.5	4.6	90.7	6.9	79.7	76.7	91.5	87.4
	300	916	14.7	5,191,673	22.3	32.9	32.3	34.8	24.9	5.3	3.0	73.6	14.5	51.4	55.4	46.0	37.4
	310	478	7.7	2,140,129	9.2	11.1	81.0	7.9	2.2	3.5	1.5	82.1	2.8	73.0	52.2	98.5	52.6
	320	100	1.6	464,375	2.0	45.9	27.2	26.9	23.1	1.5	2.0	70.6	26.8	16.3	15.9	11.3	18.6
	Total	6,213	100.0	23,235,149	100.0	21.9	49.6	28.4	21.2	3.4	2.6	62.7	5.6	32.3	30.1	47.4	34.1
2001	Manufacturing	4,247	62.5	20,382,041	56.6	25.9	46.1	28.0	18.6	4.9	2.6	77.4	10.9	46.1	44.0	58.1	43.8
	Machinery	2,121	31.2	14,825,518	41.2	29.1	40.1	30.9	19.9	5.8	2.9	79.3	13.7	52.6	51.6	62.4	47.6
	290	381	5.6	1,083,815	3.0	40.0	35.1	24.9	17.0	2.4	1.7	93.9	22.8	81.5	75.0	96.5	94.3
	300	1,041	15.3	8,538,606	23.7	34.4	31.2	34.4	22.0	7.4	2.8	77.6	15.6	54.3	55.8	55.7	52.4
	310	582	8.6	4,575,159	12.7	8.1	66.1	25.8	16.4	2.9	4.0	80.7	9.3	33.0	23.3	94.6	29.4
	320	117	1.7	627,938	1.7	40.4	42.5	17.2	12.7	2.9	1.3	72.2	14.1	79.7	78.0	91.4	74.4
	Total	6,799	100.0	35,984,433	100.0	25.0	47.5	27.5	18.8	4.2	2.5	67.2	8.2	39.5	34.6	60.0	40.7

(Continue)

Year	Industry	Number of affiliates	%	Total purchases (millions JPY)	%	By-origin purchases ratio (%)						Intra-firm transaction ratio (%)					
						Japan			Third countries			Japan			Third countries		
						Local	East Asia	North America	Europe	Local	East Asia	North America	Europe	Local	East Asia	North America	Europe
(b) Purchases																	
1992	Manufacturing	1,463	56.3	3,383,818	43.3	37.9	48.4	13.7	8.1	1.6	0.0	78.2	4.2	42.7	50.2	47.7	-
	Machinery	715	27.5	2,465,990	31.5	46.2	43.4	10.3	8.3	1.3	0.0	84.4	2.0	62.6	58.8	80.8	-
	290	91	3.5	138,472	1.8	47.8	49.0	3.3	0.7	1.1	0.3	93.9	4.5	49.7	84.8	80.3	23.9
	300	416	16.0	1,469,212	18.8	46.7	36.6	16.7	15.2	1.1	0.1	84.6	1.9	62.5	59.8	86.6	98.1
	310	171	6.6	789,842	10.1	43.8	52.9	3.2	1.0	1.7	0.4	81.7	0.6	76.7	34.6	76.2	86.2
	320	37	1.4	68,464	0.9	60.2	34.2	5.6	0.3	0.1	0.0	85.6	17.5	4.9	100.0	0.0	-
	Total	2,597	100.0	7,817,347	100.0	34.7	38.5	26.8	11.6	1.6	0.0	82.8	5.1	21.2	33.6	36.3	-
1995	Manufacturing	2,966	64.5	6,913,965	47.5	40.3	40.3	19.4	14.4	1.4	0.7	76.5	15.1	40.8	44.9	32.6	50.7
	Machinery	1,428	31.0	5,478,894	37.6	29.3	43.3	27.5	18.6	4.7	2.7	76.2	9.3	53.6	54.3	59.1	46.3
	290	234	5.1	380,291	2.6	44.0	42.9	13.2	12.6	1.1	1.0	82.9	1.6	25.7	35.4	25.1	13.2
	300	755	16.4	2,834,205	19.5	38.9	33.8	27.3	24.8	1.3	0.2	86.0	14.1	46.5	45.9	33.1	48.2
	310	339	7.4	2,007,679	13.8	51.6	45.6	2.8	1.0	0.8	0.7	73.6	16.1	68.8	39.9	97.2	85.2
	320	100	2.2	256,719	1.8	44.3	34.9	20.8	20.6	0.1	0.1	85.9	42.4	73.7	74.5	0.0	0.3
	Total	4,600	100.0	14,558,757	100.0	31.5	36.1	32.4	14.9	1.3	1.4	69.1	14.2	23.2	36.2	44.7	27.5
1998	Manufacturing	3,835	61.7	7,501,823	49.3	35.1	43.3	21.6	18.6	1.5	0.6	58.7	7.1	44.9	47.0	44.7	31.6
	Machinery	1,809	29.1	5,764,360	37.9	36.8	41.3	21.8	20.3	1.0	0.4	61.9	6.7	49.3	50.0	51.6	21.8
	290	315	5.1	400,705	2.6	32.2	57.7	10.1	8.8	0.8	0.4	79.1	3.4	76.1	85.1	21.2	0.0
	300	916	14.7	3,711,079	24.4	37.0	35.8	27.2	26.3	0.4	0.2	64.0	6.5	49.7	50.8	24.0	7.4
	310	478	7.7	1,380,996	9.1	37.2	53.4	9.4	6.1	2.5	0.7	43.8	5.2	48.4	36.2	89.5	17.0
	320	100	1.6	271,580	1.8	41.2	40.2	18.6	14.5	2.6	1.5	72.9	20.5	22.6	22.3	0.0	65.3
	Total	6,213	100.0	15,222,761	100.0	33.4	41.1	25.5	20.7	1.5	1.3	59.3	9.9	35.6	39.4	41.8	15.4
2001	Manufacturing	4,247	62.5	13,780,804	51.5	35.8	43.3	21.0	18.6	1.0	0.6	66.0	9.5	42.0	42.6	43.1	19.2
	Machinery	2,121	31.2	10,416,687	38.9	38.0	40.3	21.7	20.2	0.7	0.3	69.9	10.1	46.4	45.4	64.7	41.3
	290	381	5.6	785,548	2.9	36.2	59.0	4.8	4.3	0.3	0.1	67.1	9.8	48.3	48.7	40.9	56.5
	300	1,041	15.3	6,249,246	23.3	35.3	35.2	29.4	28.0	0.5	0.3	74.4	8.6	44.7	44.4	33.3	39.0
	310	582	8.6	2,945,237	11.0	46.5	47.3	6.2	3.9	1.6	0.4	59.6	13.7	71.4	65.4	98.2	46.2
	320	117	1.7	436,656	1.6	42.5	49.9	7.7	7.4	0.0	0.2	68.5	11.4	52.1	52.4	79.0	26.3
	Total	6,799	100.0	26,783,504	100.0	33.9	42.5	23.6	19.3	1.8	1.2	62.6	12.9	39.6	42.5	38.2	10.4

Data source: authors' calculation, based on METI database.

Note: machinery industries are general machinery (290), electric machinery (300), transport equipment (310), and precision machinery (320).

Table 8 Intra-firm and arm's length transactions by Japanese electric machinery affiliates in East Asia

														(millions JPY, %)			
		Japanese affiliates in East Asia				Japanese affiliates in NIEs4				Japanese affiliates in ASEAN4				Japanese affiliates in China			
		1992	1995	1998	2001	1992	1995	1998	2001	1992	1995	1998	2001	1992	1995	1998	2001
(a) Sales																	
Value		2,872,411	5,107,148	5,191,673	8,538,606	1,705,646	2,792,722	2,161,123	3,541,688	1,082,829	1,984,190	2,234,930	3,594,633	69,785	311,034	749,951	1,297,524
Share																	
(i)	Japan	27.2	28.7	32.9	34.4	24.7	22.6	28.1	30.3	27.7	36.2	41.9	40.0	81.2	29.7	22.5	32.2
	-intra-firm	24.5	25.6	24.2	26.7	23.3	19.9	19.9	18.0	23.1	32.1	31.8	35.7	80.7	28.3	15.8	26.5
	-arm's length	2.7	3.2	8.7	7.7	1.4	2.7	8.2	12.3	4.6	4.1	10.1	4.4	0.4	1.4	6.7	5.8
(ii)	Local	45.7	38.0	32.3	31.2	52.2	45.4	44.2	41.4	38.4	29.3	17.2	18.5	13.4	34.1	40.8	37.2
	-intra-firm	3.7	3.4	4.7	4.9	5.0	3.2	5.6	4.1	2.3	3.8	3.7	5.6	0.0	2.5	4.5	5.7
	-arm's length	42.0	34.6	27.6	26.3	47.2	42.2	38.7	37.4	36.2	25.5	13.4	12.9	13.4	31.6	36.3	31.6
(iii)	Other East Asia	17.7	19.6	24.9	22.0	16.3	17.4	18.8	16.4	20.6	20.3	28.4	26.8	5.1	30.8	31.7	22.0
	-intra-firm	9.5	11.6	13.8	12.3	5.2	9.2	6.4	7.5	15.1	11.7	15.8	14.2	5.1	27.9	27.2	17.0
	-arm's length	8.2	7.9	11.1	9.7	11.0	8.1	12.3	8.9	5.4	8.6	12.6	12.6	0.0	2.9	4.5	5.0
(i+ii+iii)	East Asia (total)	90.6	86.3	90.1	87.6	93.1	85.3	91.1	88.1	86.7	85.9	87.4	85.3	99.8	94.6	95.0	91.4
	-intra-firm	37.6	40.6	42.7	43.9	33.5	32.3	31.9	29.6	40.5	47.6	51.3	55.4	85.9	58.6	47.5	49.1
	-arm's length	53.0	45.7	47.4	43.8	59.6	53.0	59.2	58.6	46.2	38.2	36.1	29.9	13.8	35.9	47.5	42.3
(b) Purchases																	
Value		1,469,212	2,834,205	3,711,079	6,249,246	757,256	1,454,721	1,700,051	2,652,588	654,155	1,156,828	1,451,967	2,602,418	46,952	209,214	532,101	919,016
Share																	
(i)	Japan	46.7	38.9	37.0	35.3	48.7	37.8	42.5	40.8	42.1	37.1	33.7	28.3	83.6	53.3	33.3	38.3
	-intra-firm	39.5	33.5	23.7	26.3	43.2	33.6	27.8	33.1	32.8	30.7	21.7	19.4	78.4	45.1	19.4	24.9
	-arm's length	7.2	5.4	13.3	9.0	5.5	4.2	14.7	7.7	9.4	6.4	12.0	8.9	5.2	8.2	13.9	13.4
(ii)	Local	36.6	33.8	35.8	35.2	34.3	38.4	36.4	31.3	39.7	31.2	36.0	38.7	16.1	18.7	33.7	37.3
	-intra-firm	0.7	4.8	2.3	3.0	0.3	7.5	2.6	3.6	0.7	1.8	2.1	2.1	6.3	1.8	2.6	4.1
	-arm's length	35.9	29.0	33.5	32.2	33.9	30.8	33.8	27.7	39.0	29.4	33.9	36.6	9.9	16.9	31.1	33.2
(iii)	Other East Asia	15.2	24.8	26.3	28.0	15.9	20.4	20.7	26.3	15.9	30.1	29.1	31.2	0.1	27.0	32.1	23.8
	-intra-firm	9.1	11.4	13.4	12.4	15.0	12.0	11.1	12.8	3.5	7.9	10.1	10.5	0.1	22.4	27.1	16.1
	-arm's length	6.1	13.4	12.9	15.6	1.0	8.4	9.6	13.5	12.5	22.2	19.0	20.7	0.0	4.6	5.0	7.8
(i+ii+iii)	East Asia (total)	98.5	97.5	99.1	98.5	98.9	96.6	99.5	98.4	97.8	98.4	98.8	98.2	99.8	99.0	99.1	99.5
	-intra-firm	49.3	49.6	39.4	41.7	58.6	53.1	41.5	49.5	36.9	40.4	33.9	32.0	84.8	69.3	49.1	45.0
	-arm's length	49.2	47.9	59.8	56.8	40.4	43.5	58.1	48.9	60.9	58.0	64.8	66.2	15.0	29.7	50.0	54.4

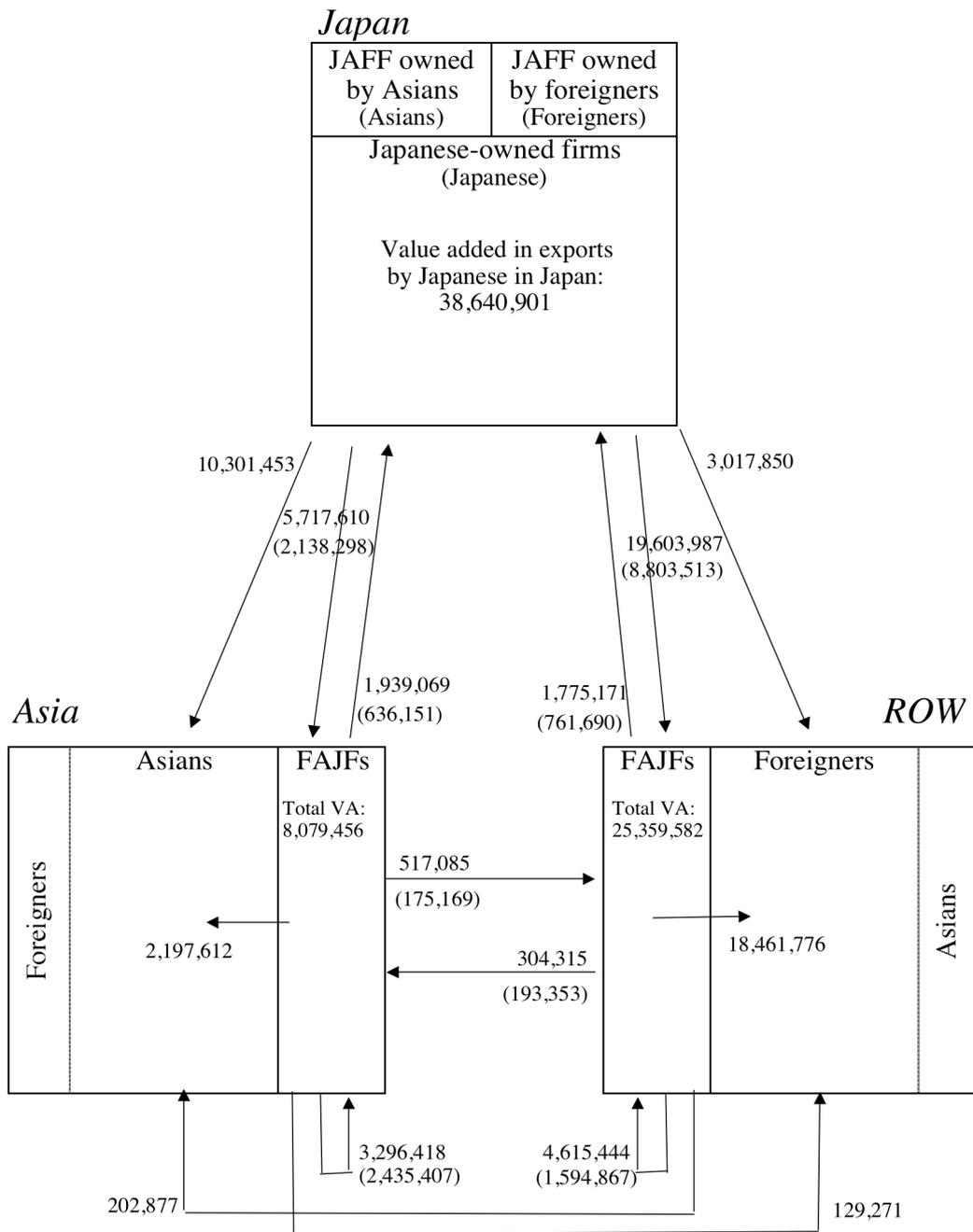
Data source: author's calculation, based on METI database.

Table 9 Intra-firm and arm's length transactions by Japanese transport equipment affiliates in East Asia

(millions JPY, %)																	
		Japanese affiliates in East Asia				Japanese affiliates in NIEs4				Japanese affiliates in ASEAN4				Japanese affiliates in China			
		1992	1995	1998	2001	1992	1995	1998	2001	1992	1995	1998	2001	1992	1995	1998	2001
(a) Sales																	
Value		1,998,597	3,094,685	2,140,129	4,575,159	811,382	757,806	556,605	829,102	973,662	1,920,034	842,530	2,379,450	35,175	145,384	281,265	696,193
Share																	
(i)	Japan	1.7	2.2	11.1	8.1	2.3	1.9	3.1	3.1	1.8	2.5	25.3	9.4	1.5	5.5	7.9	14.0
	-intra-firm	1.3	1.9	9.1	6.5	1.1	1.6	1.4	2.7	1.7	2.1	21.0	7.1	1.2	5.2	7.0	12.2
	-arm's length	0.5	0.3	2.0	1.6	1.2	0.2	1.7	0.4	0.1	0.5	4.3	2.3	0.2	0.3	0.9	1.8
(ii)	Local	92.6	92.8	81.0	66.1	92.2	92.8	91.0	84.1	92.3	91.9	59.9	54.4	92.4	87.9	88.4	82.4
	-intra-firm	6.7	25.3	2.3	6.1	0.6	22.7	5.3	6.3	11.8	34.3	3.2	8.7	0.0	0.3	0.4	0.8
	-arm's length	85.9	67.4	78.8	59.9	91.6	70.1	85.7	77.8	80.5	57.6	56.6	45.7	92.4	87.5	88.0	81.6
(iii)	Other East Asia	0.8	0.8	2.2	16.4	1.6	0.7	2.9	7.0	0.5	0.9	3.6	21.8	0.0	1.9	1.4	1.4
	-intra-firm	0.5	0.3	1.1	3.8	0.8	0.3	0.9	3.7	0.4	0.3	2.7	5.6	0.0	0.2	0.1	0.2
	-arm's length	0.3	0.6	1.1	12.6	0.8	0.4	2.1	3.3	0.1	0.7	0.9	16.2	0.0	1.7	1.3	1.2
(i+ii+iii)	East Asia (total)	95.1	95.8	94.3	90.6	96.1	95.4	97.0	94.2	94.6	95.3	88.7	85.7	93.9	95.2	97.7	97.9
	-intra-firm	8.4	27.5	12.5	16.5	2.5	24.6	7.5	12.7	13.8	36.6	27.0	21.5	1.2	5.7	7.5	13.2
	-arm's length	86.7	68.3	81.8	74.1	93.6	70.7	89.5	81.5	80.8	58.7	61.8	64.2	92.6	89.5	90.2	84.6
(b) Purchases																	
Value		789,842	2,007,679	1,380,996	2,945,237	215,408	388,562	418,601	478,653	512,345	1,379,720	519,594	1,658,388	6,209	90,923	171,058	394,182
Share																	
(i)	Japan	43.8	51.6	37.2	46.5	38.3	34.6	31.7	22.6	45.0	61.1	41.0	54.8	39.3	52.9	43.0	38.4
	-intra-firm	35.8	38.0	16.3	27.7	16.9	19.0	13.0	18.2	43.5	50.3	25.5	32.5	38.2	45.0	9.8	19.7
	-arm's length	8.0	13.6	20.9	18.8	21.4	15.6	18.7	4.4	1.6	10.8	15.5	22.4	1.0	7.9	33.2	18.6
(ii)	Local	52.9	45.6	53.4	47.3	59.9	64.3	60.8	62.2	51.4	35.7	46.0	39.6	40.5	43.3	52.3	57.9
	-intra-firm	0.3	7.3	2.8	6.5	0.0	0.4	5.6	0.5	0.5	9.5	4.9	10.2	0.0	24.1	0.1	0.5
	-arm's length	52.6	38.3	50.6	40.8	59.9	64.0	55.2	61.6	51.0	26.1	41.1	29.4	40.5	19.2	52.2	57.3
(iii)	Other East Asia	1.0	1.0	6.1	3.9	0.4	0.2	6.1	12.2	1.1	1.1	8.0	3.0	9.9	1.0	1.8	1.1
	-intra-firm	0.4	0.4	2.2	2.6	0.3	0.1	1.1	9.1	0.3	0.6	4.2	2.0	9.9	0.7	1.7	0.7
	-arm's length	0.7	0.6	3.9	1.4	0.1	0.2	5.0	3.1	0.9	0.5	3.8	1.0	0.0	0.2	0.1	0.4
(i+ii+iii)	East Asia (total)	97.8	98.3	96.7	97.7	98.6	99.2	98.7	97.0	97.6	97.9	95.0	97.5	89.6	97.2	97.1	97.3
	-intra-firm	36.5	45.7	21.3	36.8	17.2	19.5	19.7	27.9	44.2	60.4	34.6	44.7	48.1	69.9	11.5	20.9
	-arm's length	61.3	52.6	75.4	61.0	81.4	79.7	79.0	69.1	53.4	37.4	60.4	52.8	41.5	27.3	85.6	76.4

Data source: author's calculation, based on METI database.

Figure 9 Japanese value added embodied in sales to Asians and foreigners by Japanese: Three-country setting (2001)
 (Unit: Million JP Yen)



Data source: Table A.2.

Note: figures in parenthesis are value added embodied in arm's length transactions for the corresponding arrows.

Table A.1 Definition of machinery parts and components

HS classification

840140, 840290, 840390, 840490, 840590, 8406, 8407, 8408, 8409, 8410, 8411, 8412, 8413, 8414, 841520, 841590, 8416, 8417, 841891, 841899, 841990, 842123, 842129, 842131, 842191, 842199, 842290, 842390, 842490, 8431, 843290, 843390, 843490, 843590, 843680, 843691, 843699, 843790, 843890, 843991, 843999, 844090, 844190, 844240, 844250, 844390, 8448, 845090, 845190, 845240, 845290, 845390, 845490, 845590, 8466, 846791, 846792, 846799, 846890, 8473, 847490, 847590, 847690, 847790, 847890, 847990, 8480, 8481, 8482, 8483, 8484, 8485, 8503, 850490, 8505, 850690, 8507, 850890, 850990, 851090, 8511, 8512, 851390, 851490, 851590, 851690, 851790, 8518, 8522, 8529, 853090, 8531, 8532, 8533, 8534, 8535, 8536, 8537, 8538, 8539, 8540, 8541, 8542, 854390, 8544, 8545, 8546, 8547, 8548, 8607, 8706, 8707, 8708, 870990, 8714, 871690, 8803, 8805, 9001, 9002, 9003, 900590, 900691, 900699, 900791, 900792, 900890, 900990, 901090, 901190, 901290, 9013, 9014, 901590, 901790, 902490, 902590, 902690, 902790, 902890, 902990, 903090, 903190, 903290, 9033, 9110, 9111, 9112, 9113, 9114, 9209

Source: Ando and Kimura (2005).

Table A.2 Exports versus FDI by Japanese-owned firms in a three-country model

(Unit: Million JPY)

Category	2001		
	Exports/sales	Value-added (VA)	(%)
[1] Japanese value added in exports of Japanese-owned firms in Japan	43,643,936	38,640,901	100.0
[1-1] In exports to FAJFs (Japanese)	28,600,114	25,321,597	65.5
[1-1-1] located in Asia	6,457,898	5,717,610	14.8
<i>(intra-firm transactions)</i>	4,042,744	3,579,312	9.3
<i>(arm's length transactions)</i>	2,415,154	2,138,298	5.5
[1-1-2] located in ROW	22,142,216	19,603,987	50.7
<i>(intra-firm transactions)</i>	12,198,867	10,800,474	28.0
<i>(arm's length transactions)</i>	9,943,349	8,803,513	22.8
[1-2] In exports to Asians (non-Japanese)	11,635,235	10,301,453	26.7
[1-2-1] located in Asia	11,635,235	10,301,453	26.7
[1-2-2] located in ROW	n.a.	n.a.	
[1-3] In exports to foreigners (non Japanese&Asian)	3,408,587	3,017,850	7.8
[1-3-1] located in Asia	n.a.	n.a.	
[1-3-2] located in ROW	3,408,587	3,017,850	7.8
[2] Value added by FAJFs in Asia	35,866,630	8,079,456	100.0
[2-1] In goods and services sold to Japanese	25,594,427	5,752,573	71.2
[2-1-1] located in Japan	8,643,858	1,939,069	24.0
<i>(intra-firm transactions)</i>	5,808,067	1,302,919	16.1
<i>(arm's length transactions)</i>	2,835,791	636,151	7.9
[2-1-2] located in Asia (other FAJFs in Asia)	14,482,945	3,296,418	40.8
<i>(intra-firm transactions)</i>	3,782,886	861,011	10.7
<i>(arm's length transactions)</i>	10,700,059	2,435,407	30.1
[2-1-3] located in ROW (other FAJFs in ROW)	2,467,624	517,085	6.4
<i>(intra-firm transactions)</i>	1,631,684	341,916	4.2
<i>(arm's length transactions)</i>	835,940	175,169	2.2
[2-2] In goods and services sold to Asians (non-Japanese)	9,655,297	2,197,612	27.2
[2-2-1] located in Japan	n.a.	n.a.	
[2-2-2] located in Asia	9,655,297	2,197,612	27.2
[2-2-3] located in ROW	n.a.	n.a.	
[2-3] In goods and services sold to foreigners (non Japanese&Asian)	616,906	129,271	1.6
[2-3-1] located in Japan	n.a.	n.a.	
[2-3-2] located in Asia	n.a.	n.a.	
[2-3-3] located in ROW	616,906	129,271	1.6
[3] Value added by Japanese affiliates in ROW	99,049,925	25,359,582	100.0
[3-1] In goods and services sold to Japanese	25,673,741	6,694,930	26.4
[3-1-1] located in Japan	6,537,295	1,775,171	7.0
<i>(intra-firm transactions)</i>	3,732,275	1,013,481	4.0
<i>(arm's length transactions)</i>	2,805,020	761,690	3.0
[3-1-2] located in Asia (other FAJFs in Asia)	950,879	304,315	1.2
<i>(intra-firm transactions)</i>	346,717	110,962	0.4
<i>(arm's length transactions)</i>	604,162	193,353	0.8
[3-1-3] located in ROW (other FAJFs in ROW)	18,185,566	4,615,444	18.2
<i>(intra-firm transactions)</i>	11,901,541	3,020,577	11.9
<i>(arm's length transactions)</i>	6,284,025	1,594,867	6.3
[3-2] In goods and services sold to Asians (non-Japanese)	633,920	202,877	0.8
[3-2-1] located in Japan	n.a.	n.a.	
[3-2-2] located in Asia	633,920	202,877	0.8
[3-2-3] located in ROW	n.a.	n.a.	
[3-3] In goods and services sold to foreigners (non Japanese&Asian)	72,742,265	18,461,776	72.8
[3-3-1] located in Japan	n.a.	n.a.	
[3-3-2] located in Asia	n.a.	n.a.	
[3-3-3] located in ROW	72,742,265	18,461,776	72.8

Definition:

- FAJF: Foreign affiliates of Japanese firms that include "affiliates abroad" with no less than 10 percent ownership by Japanese parent firms and "affiliates of affiliates abroad" with more than 50% ownership by such "affiliates abroad".
- JAFF: Japanese affiliates of foreign firms with foreign share of more than one-third.
- ROW: All countries other than Japan and Asia (region).
- Japanese: Households and governments in Japan + all firms located in Japan - JAFF + FAJF .
- Asians: Households and governments in Asia + Asian-owned firms located in Asia. + affiliates of firms owned by Asians in Japan and ROW .
- Foreigners: Households and governments in ROW + foreign-owned firms located in ROW + affiliates of foreign firms in Japan and Asia.

Estimation method of three-country model

1. $([\text{Japanese total exports}] - [\text{Exports by JAFF}]) \times (1 - 0.08504) = [1-1.] + [1-2.] + [1-3.]$
- 1-1. $[1-1-1.] + [1-1-2.]$
- 1-1-1. $([\text{Imports from Japan by FAJF in Asia}] - [\text{Imports from JAFF by FAJF in Asia (n.a.)}]) \times (1 - \text{import inducement coefficient of export (IICE)})$
- 1-1-2. $([\text{Imports from Japan by FAJF in ROW}] - [\text{Imports from JAFF by FAJF in ROW (n.a.)}]) \times (1 - \text{IICE})$
- 1-2. $[1-2-1.] + [1-2-2.]$
- 1-2-1. $([\text{Japanese exports to Asia}] - [\text{Exports to Asia by JAFF (available only for exports to Asia)}]) \times (1 - \text{IICE}) - [1-1-1.] - [1-3-1.]$
- 1-2-2. $[\text{Japanese exports to p.c. nationals located in ROW (n.a.)}] \times (1 - \text{IICE})$
- 1-3. $[1-3-1.] + [1-3-2.]$
- 1-3-1. $[\text{Japanese exports to foreigners located in Asia (n.a.)}] \times (1 - \text{IICE})$
- 1-3-2. $([\text{Japanese exports to ROW}] - [\text{Exports to ROW by JAFF}]) \times (1 - \text{IICE}) - [1-1-2.] - [1-2-2.]$
2. $[\text{Sales by FAJF in Asia}] - [\text{Purchases by FAJF in Asia}] = [2-1.] + [2-2.] + [2-3.]$
- 2-1. $[2-1-1.] + [2-1-2.] + [2-1-3.]$
- 2-1-1. $[2-1.] \times [\text{Ratio of sales to Japan by FAJF in Asia}] - [2-2-1.] - [2-3-1.]$
- 2-1-2. $[2-1.] \times ([\text{Ratio of local sales by FAJF in Asia}] \times [\text{Ratio of sales to FAJF in local sales by FAJF in Asia (proxy: 0.6)}])$
- 2-1-3. $[2-1.] \times ([\text{Ratio of sales to ROW by FAJF in Asia}] \times [\text{Ratio of sales to FAJF in ROW in sales to ROW by FAJF in Asia (proxy: 0.8)}])$
- 2-2. $[2-2-1.] + [2-2-2.] + [2-2-3.]$
- 2-2-1. $[\text{Value added in goods and services sold to JAFF (owned by Asians) by FAJF in Asia (n.a.)}]$
- 2-2-2. $[2-1.] \times [\text{Ratio of local sales by FAJF in Asia}] \times [\text{Ratio of sales to Asians in local sales by FAJF in Asia (proxy: 0.4)}] - [2-1-2.] - [2-3-2.]$
- 2-2-3. $[\text{Value added in goods and services sold to Asians located in ROW by FAJF in Asia (n.a.)}]$
- 2-3. $[2-3-1.] + [2-3-2.] + [2-3-3.]$
- 2-3-1. $[\text{Value added in goods and services sold to JAFF (owned by foreigners) by FAJF in Asia (n.a.)}]$
- 2-3-2. $[\text{Value added in goods and services sold to foreigners located in Asia by FAJF in Asia (n.a.)}]$
- 2-3-3. $[2-1.] \times [\text{Ratio of sales to ROW by FAJF in Asia}] \times [\text{Ratio of sales to foreigners in sales to ROW by FAJF in Asia (proxy: 0.2)}] - [2-1-3.] - [2-2-3.]$
3. $[\text{Sales by FAJF in ROW}] - [\text{Purchases by FAJF in ROW}] = [3-1.] + [3-2.] + [3-3.]$
- 3-1. $[3-1-1.] + [3-1-2.] + [3-1-3.]$
- 3-1-1. $[3-1.] \times [\text{Ratio of sales to Japan by FAJF in ROW}] - [3-2-1.] - [3-3-1.]$
- 3-1-2. $[3-1.] \times ([\text{Ratio of sales to Asia by FAJF in ROW}] \times [\text{Ratio of sales to FAJF in Asia in sales to Asia by FAJF in ROW (proxy: 0.6)}])$
- 3-1-3. $[3-1.] \times ([\text{Ratio of local sales by FAJF in ROW}] \times [\text{Ratio of sales to FAJF in local sales by FAJF in ROW (proxy: 0.2)}])$
- 3-2. $[3-2-1.] + [3-2-2.] + [3-2-3.]$
- 3-2-1. $[\text{Value added in goods and services sold to JAFF (owned by Asians) by FAJF in ROW (n.a.)}]$
- 3-2-2. $[3-1.] \times [\text{Ratio of sales to Asia by FAJF in ROW}] \times [\text{Ratio of sales to Asians in sales to Asia by FAJF in ROW (proxy: 0.4)}] - [3-1-2.] - [3-3-2.]$
- 3-2-3. $[\text{Value added in goods and services sold to Asians located in ROW by FAJF in ROW (n.a.)}]$
- 3-3. $[3-3-1.] + [3-3-2.] + [3-3-3.]$
- 3-3-1. $[\text{Value added in goods and services sold to JAFF (owned by foreigners) by FAJF in ROW (n.a.)}]$
- 3-3-2. $[\text{Value added in goods and services sold to foreigners located in Asia by FAJF in ROW (n.a.)}]$
- 3-3-3. $[3-1.] \times ([\text{Ratio of local sales by FAJF in ROW}] \times [\text{Ratio of sales to foreigners in sales to ROW by FAJF in ROW (proxy: 0.8)}]) - [3-1-3.] - [3-2-3.]$

Data sources: MOF website (<http://www.mof.go.jp/>) for exports of Japan; METI (2003a) for exports of JAFF; MITI (2003b) for sales and purchases of FAJF, Statistics Bureau website (<http://www.stat.go.jp/>) for the import inducement coefficient of export in Japan for 2000.