

Preliminary draft
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Fragmentation and Parts and Components Trade:
Comparison between East Asia and Europe

July 2005

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Abstract

This paper argues that the fragmentation theory is suited for explaining the mechanics of international production/distribution networks in East Asia, in contrast with the traditional horizontal product differentiation model fitted for intra-industry trade in Europe. Using finely disaggregated international trade data, the patterns of international trade in East Asia and Europe, particularly trade in machinery parts and components, are carefully examined, and the gravity equation approach is applied to check the validity of theoretical framework.

1. Introduction

It has increasingly been widely recognized that the formation of international production/distribution networks are one of the most important phenomena in current East Asia. Networks are found in various industries, but most important, both qualitatively and quantitatively, are those in machinery industries including general machinery, electric machinery, transport equipment, and precision machinery. Machinery industries involve 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) the significance in each economy, (ii) the extensiveness covering a number of countries in the region, and (iii) the sophistication in their structure consisting of both intra-firm and arm's-length transactions.¹

To understand the mechanics of international production/distribution networks in East Asia, we must develop a new theoretical framework explaining production-process-wise vertical division of labor. We observe a drastic shift of trade pattern from one-way trade to intra-industry trade in East Asia, but most of the intra-industry trade is “vertical,” i.e., unit prices of exports and imports widely differ, rather than “horizontal.”² The well-established model of intra-industry trade, pioneered by Krugman (1980) and Helpman and Krugman (1985), is based on horizontal product differentiation and well analyzes the mechanics of horizontal intra-industry trade among developed countries such as EU. It does not, however, seem to be effective in explaining the trade pattern in East Asia. Rather, the fragmentation theory initiated by Jones and Kierzkowski (1990) provides a clue to analyzing the structure of production/distribution networks in East Asia.

This paper argues that the fragmentation theory is suited for explaining the mechanics of international production/distribution networks in East Asia in contrast with the traditional horizontal product differentiation model. Using finely disaggregated international trade data, the patterns of international trade in East Asia and Europe, particularly trade in machinery parts and components, are examined, and the gravity equation approach is applied to check the validity of theoretical framework.

The paper plan is as follows: the next section reviews two opposing modeling strategies for intra-industry trade and provides tentative characterization of

¹ See Ando and Kimura (2003).

² See Fukao, Ishito, and Ito (2003) and Ando (2005).

international trade in East Asia and Europe. Section 3 reviews dramatic development of machinery parts and components trade in East Asia, contrasting with trade in Europe. Section 4 provides some evidences for the existence of economic conditions encouraging fragmentation in East Asia. Section 5 conducts the gravity equation regressions and confirms the validity of our theoretical framework. The last section concludes.

2. Two alternative models of machinery parts and components trade

In the international trade literature, how to formalize intra-industry trade in rigorous theoretical models was a large and important theoretical agenda in the 1970s and 1980s. We empirically knew that a substantial portion of international trade was intra-industry trade, i.e., exports and imports occurred at the same time, even at the most disaggregated level of commodity classification. In particular, international trade among developed countries such as European countries contained massive intra-industry trade, which was not well explained by traditional comparative advantage theories such as the Ricardian model and the Heckscher-Ohlin model. Krugman (1980) and its educational version (Helpman and Krugman (1985)) were pioneering works in this context where horizontally differentiated products, often formulated along Dixit and Stiglitz (1977), are traded back-and-forth, i.e., horizontal intra-industry trade emerges.

There are a large number of variations in this type of international trade models, but some common elements can be pointed out. First, the technology of producing differentiated products is often specified as high-tech or physical/human capital intensive so that developed countries produce such products. Second, products are typically specified as horizontally differentiated at theoretical convenience so that horizontal symmetry is kept both on the demand and supply side. Third, theoretical formation of monopolistic competition generates variety effects in addition to price/quantity effects when international trade is liberalized. Fourth, the implication of transport cost has been formulated in various ways. But, particularly in the case of differentiated products, transport cost is supposed to penalize trade to a greater extent than the case of homogeneous products. These settings are proven to be suited for horizontal intra-industry trade among developed countries such as core EU countries. Let us call such a theoretical framework the “Europe” model.

On the other hand, the recent trade pattern in East Asia does not seem to fit such a model. We observe an explosive increase in intra-industry trade, particularly in machinery sectors, but it is mostly “vertical” intra-industry trade rather than

“horizontal.” Massive transactions of machinery parts and components are observed in international production/distribution networks including a number of countries in the region with different income levels and at different development stages. Technological conditions seem to be different in each production process located across the region, and vertical linkages in production, rather than product differentiation, seem to be important in international transactions. A class of fragmentation models seems to work much better in the East Asian context.

The fragmentation theory was first proposed by Jones and Kierzkowski (1990) and has been developed in both theoretical and empirical literature.³⁴ Fragmentation of production processes takes place when (i) production cost *per se* in fragmented production blocks can be substantially reduced and (ii) service link cost connecting remotely located production blocks is not prohibitively high. The reduction in production cost *per se* is realized by taking advantage of different production conditions. A new location for a production block must have some sort of location advantages that cannot be obtained at the original position; such location advantages could be low wages, inexpensive infrastructure services, the existence of supporting industries and industrial agglomeration, favorable policy environment, and others. Service link cost must be low enough not to cancel out production cost advantages; it comes from tariffs and other trade impediments, transport cost, telecommunication cost, and various kinds of coordination cost among production blocks. Let us call this model the “East Asia” model.

In the following, we will analyze the statistical data of international trade, particularly trade in machinery parts and components, having the sharp contrast of two models in mind.

3. A dramatic increase in parts and components trade in East Asia

In this section, we examine dramatic changes in trade in machinery parts and components in East Asia, using the European case as a reference. Our analysis concentrates on machinery sectors including general machinery, electric machinery, transport equipment, and precision machinery, since machinery sectors have played the most important role in the production/distribution networks in East Asia. In

³ Also see Arndt and Kierzkowski (2001), Deardorff (2001), and Cheng and Kierzkowski (2001) for the fragmentation theory.

⁴ Kimura and Ando (2005) propose the conceptual framework of two-dimensional fragmentation, i.e., fragmentation in terms of geographical distance and disintegration, as an effective tool for understanding production/distribution networks in East Asia. This paper, however, primarily focuses on traditional “geographical distance” type fragmentation.

particular, we focus on machinery parts and components accompanied with the fragmentation of vertical production processes. To analyze the change in transactions in machinery parts and components, we make use of trade data in the Standard International Trade Classification (SITC) Revision 2.⁵ Appendix 1 provides the code list of parts and components. Countries in our dataset are listed in Appendix 2.

Table 1 tabulates the magnitude of exports in machinery parts and components and compares its significance with all commodities, machinery goods, and final machinery goods. The worldwide trade in machinery parts and components has grown from \$336 billion in 1987 to \$1,299 billion in 2003, while trade in total commodities and in machinery goods during the same period have increased from \$2,127 billion to \$6,526 billion and from \$837 billion to \$2,913 billion. Consequently, in the worldwide trade, the share of machinery parts and components in total commodities and in machinery goods increased from 16% to 20% and from 40% to 45%.

== Table 1 ==

East Asia has achieved faster export growth in trade in all categories, i.e., total commodities, machinery goods, final machinery goods, and machinery parts and components, than the world average. A rapid increase in parts and components exports in East Asia is particularly noteworthy. The value of machinery parts and components exports increased by more than 500% during the period of 1987-2003. As a result, the share of parts and components exports in total commodities and machinery goods exports in East Asia increased from 17% to 27% and from 34% to 48%. Due to such astounding growth in parts and components exports, East Asia raised its share in the world, as Figure 1 depicts. NIES3, China, and ASEAN enjoyed rapid growth in their shares from 8% in 1987 to 25% in 2003. With exports by Japan, East Asia occupies 36% out of the world total exports, almost equivalent to exports by European countries.

== Figure 1 ==

The intra-regional trade in machinery parts and components in East Asia experienced more drastic changes. Table 2 presents the importance of the intra-regional trade relative to the inter-regional trade in East Asia and Europe. The

⁵ Our coverage of parts and components is much broader than that by Ng and Yeats (2001), who also used the SITC Revision 2 data.

intra-regional machinery parts and components trade in East Asia increased by 1000%, and the intra-regional share rose from 30% in 1987 to 53% in 2003. Figure 2 shows that main players in intra-regional trade have also changed. In 1987, a large portion of machinery parts and components exports were conducted by Japan and NIES3, which accounts for 86% of all the intra-regional trade in machinery parts and components. Since then, developing countries, namely ASEAN4 and China, have become important exporters of machinery parts and components. The ratio of machinery parts and components exports by ASEAN4 and China reached 42% in 2003. We here observe a massive “magnification effect” of parts and components trade on the growth of intra-regional trade.⁶

== Table 2 ==

== Figure 2 ==

Europe has experienced slower growth in trade in machinery parts and components than the world average (see Table 1 again). As a result, Europe has lowered its share of machinery parts and components exports in the world from 48% in 1987 to 40% in 2003, as depicted in Figure 1. Intra-regional trade in Europe, particularly machinery parts and components trade, has also grown at much slower pace than in East Asia (Table 2). As presented in Figure 3, most of the intra-regional trade in machinery parts and components remains trade among Western/Northern European countries though we observe the emergence of trade with Eastern European countries.

== Figure 3 ==

4. Location advantages and service link costs in East Asia

In contrast with the Europe model, the East Asia model requires a set of conditions in the formation of international production/distribution networks. One category of conditions is on the actors' side; corporate firms in the region, particularly MNEs, must have technological and managerial capability to develop such networks. The enhancing competitiveness of East Asian MNEs in the machinery sector as well as technological progress that supports fragmentation such as modulation technique

⁶ As for the concept of magnification effect, see Yi (2003).

seems to be an essential factor in 1990s and after. Experiences in managing inter-firm production networking such as Japanese vertical “shitauke (subcontracting),” Taiwanese horizontal subcontracting, and processing deal trade in the Hong Kong-Guangdong nexus perhaps worked in the designing of East Asian production/distribution networks.

On the other hand, given the capability of prime actors, conditions on the background economic environment are also required. The fragmentation theory states that fragmentation is chosen when (i) production cost *per se* in production blocks can be reduced and (ii) service link cost connecting remotely located production blocks is not prohibitively high. Although it is extremely difficult to quantitatively measure such elements, this section tries to argue some of the background conditions.

The reduction of production cost *per se* in fragmentation comes from differences in location advantages. If the location conditions are the same as the original position, fragmentation does not make sense. Location advantages consist of various economic elements, and a new location for a production block must have a different set of location advantages from the original position. This economic logic generates a sharp contrast with the Europe model where a “similar” set of location advantages allows horizontal product differentiation.

Location advantages consist not only of factor prices (namely wages) but also of agglomeration effects, infrastructure services, policy environment, and others. Different development stages would provide diversified location advantages. Figure 4 ranks countries selected in the previous section from the left according to per capita GDP in 1987, and figure 5 is for 2003. East Asian countries are presented as dark-colored bars while European countries have light-colored bars. We can immediately see that most of the European countries have high income while the income levels of East Asian countries are of wide variety. China and ASEAN 4 except Malaysia are placed in the right hand side of Poland that has the lowest income level in European countries in our sample. Even NIES3 are located at around medium ranks of European countries. This is one of the evidences that East Asian countries present different sets of location advantages in the formation of production/distribution networks. We do not of course claim that income or wage level is the only factor for production cost reduction. But, with other elements of location advantages, it can be a powerful attractor of fragmented production blocks.

== Figure 4 & 5 ==

Do we find any information on service link cost? Is there any direct or indirect evidence that service link cost has reduced over time or at least it has been kept at low level during the explosive expansion of production networking in East Asia? Service link cost again consists of various elements, and we intuitively know that intangible portion of service link cost would be of particular importance. We can however obtain some observations suggesting lowering service link cost.

First, we observe that trade impediments in East Asia, particularly those imposed on machinery parts and components, have steadily been lowered. The most visible portion of service link cost is tariffs imposed on trade between production blocks. Figures 6 and 7 plot trade-weighted averages of MFN rates on machinery and transport equipment and tariff burden rates, i.e., total tariff revenues over import values for all commodities, from the late 1980s to the present. These figures indicate steady tariff reduction in East Asian countries. In particular, the decline in trade-weighted tariffs in the latter half of the 1990s reflects APEC-led trade liberalization initiative on electronic parts and components. The extensive use of duty-drawback system, i.e., tariff rebate system for imported intermediated inputs in order to produce exported products, also pushed down the trade-weighted trade barriers. These changes in international commercial policies accelerated shifts in development strategies in these countries from fostering import-substitution-type industries to promoting export-oriented or network-forming-type industries.

== Figure 6 & 7 ==

Second, we have some evidences on the decline in physical transport cost. Hummels (1999) argues that the air freight cost has dramatically fallen all over the world. JETRO (2002) proves that the ocean shipping cost in East Asian countries has decreased. The world trade has shifted its relative weight from low value-over-weight manufactures to high value-over-weight, and air transport has come to the center stage in transportation. As a result, the overall trade-weighted average of transport cost has remarkably declined over the last 30 years as shown in Hummels (1999).

Third, we can also detect changes in the time aspect of trade cost. There is a recent literature emphasizing time cost in transportation. Hummels (2001) pointed out that time cost could matter particularly for trade in parts and components. Harrigan and Venables (2004) argue with some illustrative theoretical models that time cost is qualitatively different from direct monetary cost. For example, long supply chains that are mostly accompanied by fragmentation require storage costs, inventory

costs due to buffering the variability of delivery dates, and the like to firmly connect those chains.

Hummels (2001) also shows that the shift from shipping transport to airlift or from regular to faster ships over the period 1950-1998 has reduced the tax equivalent of time costs from 32% to 9%. In general, air transportations cut not only the delivery time between ports but also the time of the customs formalities. In East Asian countries, the time lost in customs for air transportation is less than half of that for ocean transportation (JETRO, 2002). In Malaysia, for instance, the time in air is around 7 hours while the time in ocean is 3 days.⁷ Thus, the increase in transport by air relative to that by shipping significantly reduced the overall time costs. We may also be able to conceive a decline in time cost from the improvement of port efficiency or simplification of customs formalities, since infrastructure is likely to have a considerable effect on the time cost of trade as argued in Anderson and Wincoop (2004).

Overall, it is difficult to directly assess the major portion of service link cost in statistical figures. However, we observe the explosive expansion of intra-regional transactions, and this fact itself must be supported by either the reduction of service link cost or at least the maintained low level of service link cost in East Asia. While the world container port traffic increased from 86 million TEU in 1990 to 303 million TEU in 2003, the traffic in East Asian countries during the same period increased from 31 million TEU to 142 million TEU (Containerisation International Yearbook). World international traffic flows by air during the same period also increased from 9 million tons to 20 million tons. The international traffic within Asia quadrupled from 1994 to 2003, as shown in figure 8, and became the largest route in the world (World Air Transportation Statistics).

== Figure 8 ==

5. Gravity equation analysis

Although the direct measurement of fragmentation forces is difficult, some econometric analysis reveals the nature of production networking. This section investigates the characteristics of trade in parts and components among East Asian countries where trade is strongly motivated by fragmentation forces, in contrast with the European case in which trade in horizontally differentiated products is dominant.

⁷ Three days include transport time between a gate of port and the major industrial estate, namely Shah Alam industrial estate.

5.1. Model specification

It is well known that the gravity equation can be supported by various kinds of theoretical models, and we here take advantage of the properties in order to characterize machinery trade in East Asia and Europe. We claim that two regions follow different models: the East Asia model and the Europe model that we presented in section 2. If so, we should detect differences in statistical inferences, particularly in the implication of geographical distance and differences in income level between exporting and importing countries. By using bilateral machinery trade data of 56 countries listed in Appendix 2 in 1987, 1995, and 2003, we conduct gravity model regressions.

For each year, we estimate two versions of gravity equations. The first is a usual gravity equation as follows:

$$\ln EX_{ij} = \beta_0 + \beta_1 \ln DIS_{ij} + \beta_2 \ln EXGDP_i + \beta_3 \ln IMGDP_j + \beta_4 \ln EXPERGDP_i + \beta_5 \ln IMPERGDP_j + \varepsilon_{ij}, \quad (1)$$

where EX_{ij} , DIS_{ij} , $EXGDP_i$, $IMGDP_j$, $EXPERGDP_i$, and $IMPERGDP_j$ denote trade values from country i to country j , the distance between countries i and j , exporter i 's and importer j 's GDP, and exporter i 's and importer j 's per capita GDP, respectively. We also add the East Asia dummy and the Europe dummy, the value of which is 1 when trade in intra-regional and 0 otherwise, and language dummy, the value of which is 1 when trading countries have a common language and 0 otherwise. The second gravity equation is specifically designed so as to distinguish two models; we introduce income gaps between trading countries instead of both countries' income level as follows:

$$\ln EX_{ij} = \beta_0 + \beta_1 \ln DIS_{ij} + \beta_2 \ln EXGDP_i + \beta_3 \ln IMGDP_j + \beta_6 \ln GAP_{ij} + \varepsilon_{ij}, \quad (2)$$

where GAP_{ij} denotes gaps in GDP per capita between exporter i and importer j . The same set of dummy variables is added. The definitions and sources of all variables are listed in Appendix 3.

For each regression equation, we separately conduct regression for bilateral trade both in final goods and in parts and components. To test whether final products and parts and components have different trade patterns, we conduct the Wald test with the null hypothesis that all coefficients are identical in both equations. In general, separate estimation of two regressions may be accompanied with correlated estimation errors. That is, the error term in final goods equation could possibly be non-orthogonal

to that in parts and components equation. This correlation is plausible because the unobservable, such as nontariff barriers, would simultaneously affect *both* final goods trade and parts trade. Therefore, we should usually apply the generalized least squares (GLS) method that gives us more efficient estimators than the ordinary least squares (OLS) estimators. However, we here use the method of the OLS by equation⁸ because the same regressors show up in each equation and therefore the OLS estimates become equivalent to the GLS estimates.

5.2. Estimation results

Table 3 reports the results of full-sample estimations. With both final goods and parts equations, the coefficients for standard variables have expected signs and are statistically significant; trade values are positively correlated with the market size of trading countries and are adversely affected by geographic distances between the countries, with their signs and statistical significance being quite stable over time.⁹

== Table 3 ==

The null hypothesis in the Wald test is rejected in all sets of equations, confirming our belief that the mechanism of trade in parts and components is different from that of trade in final goods. This result implies that the estimation based on aggregate trade data leads to biases of estimators as argued above though their directions and magnitudes remain unknown.

Regional dummies present a sharp contrast. The coefficients for the East Asia dummy are positive for both final goods and parts equations, indicating that East Asia has been engaging more machinery trade in East Asia than the gravity model predicts throughout the sample period. On the other hand, the coefficients for the Europe dummy in the first gravity equation, i.e., equation (1), become significantly negative for both final goods and parts, which indicates that intra-regional trade in Europe has been

⁸ We perform the GLS estimation in order only to obtain the covariances between the estimates from different equations, which are needed to perform the Wald test.

⁹ Although we do not report the detailed result here, we performed additional checks on the robustness of our findings. As in the standard gravity approach, we added the adjacency dummy, ADJ, which is a binary variable taking the value 1 if trading partners share a common land border and 0 otherwise. However, since the adding the variable makes no qualitative change in the findings, and since the high correlation is found between ADJ and distance variable, we omitted the variable from our regressions. Besides, since trade data was censored from below at zero, we performed the TOBIT estimation. Yet again, we obtained quite similar results to the reported ones.

smaller than the gravity equation predicts.

The coefficients for the income gap variable in equation (2) are all positive. This means that in general partners with a wide income gap tend to trade more. An interesting observation is that introducing the gap variable leads to changes in other estimated coefficients, particularly those for regional dummies. The coefficients for the East Asia dummy become smaller. This implies that the intra-regional trade in East Asia is partly explained by the income gap or differences in location advantages. Introducing the income gap variable, on the other hand, turns the coefficients for the Europe dummy into significantly positive in final goods equations and into insignificant in the parts equations. The results for the parts equations mean that the intra-regional parts trade in Europe is within the prediction of the gravity equation after controlling for the income gap between trade partners.

To place a clearer focus on the contrast between East Asia and Europe, we use only intra East Asia and intra Europe bilateral trade respectively and examine how coefficients for distance and income gap are different between two regions. Tables 4 and 5 summarize the regression results.¹⁰

== Table 4 & 5 ==

Three important facts are found in these tables, verifying the validity of the East Asia model and the Europe model. First, the coefficients for income gap present a sharp contrast between two regions: positive in East Asia while negative in Europe. In East Asia, a wide gap in income level between exporter and importer is associated with a large flow of parts and components between them. This finding is consistent with the East Asia model where vertical division of labor with fragmentation is prevalent in this region. Differences in location advantages, one of which comes from differences in income level, are effectively utilized in production networking. In Europe, on the other hand, the smaller income gaps trading partners have, the more they trade parts and components. This implies that trade in horizontally differentiated products are dominant and consequently smaller income gaps provide firms more incentive to trade parts and components, as the Europe model predicts.

Second, absolute values of coefficients for distance are much smaller in East Asia than in Europe. The East Asia model argues that fragmentation occurs when (i) the saving of production cost per se in production blocks is large and (ii) service link cost

¹⁰ The regression results in completed goods equations are unreported to save paper space, which are available from the authors upon request.

connecting production blocks is not prohibitively high. Distance is related to both elements. As for (i), one of the explanatory variable, income gap, takes care of a part of the differences in location advantages, but, even after controlling it, distance may still represent other elements of differences in production conditions such as the provision of infrastructure services and favorable policy environment. As for (ii), distance surely represents an important portion of service link cost. Although it is difficult to decompose these two elements, small coefficients for distance can be interpreted as indicating favorable economic conditions for fragmentation in East Asia. In the case of Europe, on the other hand, distance penalizes parts and components trade strongly as the Europe model suggests.

Third, we observe some notable changes over time in East Asia. In 1987, the coefficient on income gap is positive and statistically significant. However, the magnitude of the coefficient declines over time and ends up with being insignificant in 2003. On the other hand, the coefficient on distance in 1987 is not statistically different from zero, while being significant both in 1995 and 2003. This may be interpreted as follows. Before the formation of international production/distribution networks in East Asia, Japan was the only predominant exporter of parts and components in East Asia. Developing countries such as Malaysia and Thailand scarcely traded parts and components at that. Therefore, in 1987, distance did not explain the cross-sectional variation of trade in parts and components in our gravity equations. At the same time, since Japan was overwhelmingly dominant in exporting parts and components, the coefficient for income gap was large. In the 1990s, developing countries in East Asia started to participate in the networks and engage in transactions of parts and components. Accordingly, distance becomes significant against trade in parts and components. On the other hand, now that trade between developing countries with relatively small income disparity accounts for a certain fraction of parts trade in this region, the coefficient for income gap gets smaller than in the past.

6. Concluding remarks

The results of our gravity equation analysis are consistent with our claim that important elements in the fragmentation theory, differences in location advantages and service link cost, are empirically relevant and play significant roles in determining the magnitudes of trade in machinery parts and components in East Asia. In addition, we observed changes in coefficients for those factors, suggesting substantial development in the characteristics of international production/distribution networks in East Asia.

Our analytical approach of contrasting the East Asia model with the Europe model successfully differentiates alternative motivations for trade in machinery parts and components in East Asia and Europe.

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Appendix 1. Definition of machinery parts and components trade

In the choice of international trade data set that applied in our analysis, the following conditions are considered:

1. Whether it is detailed enough to identify whether the items are parts and components or finished products.
2. Whether it is sufficiently long in time series so that we can analyze trade in parts and components before and after the formation of production/distribution networks in East Asia; i.e. from the 1980s to present.
3. Whether it is comprehensive enough to cover important players in East Asia; namely, Japan, Republic of Korea, China, Hong Kong, the Philippines, Thailand,

Singapore, Malaysia, and Indonesia.

The SITC Revision 1 does not satisfy the first condition, and the harmonized system (HS) and the SITC Revision 3 do not satisfy the second condition. Therefore, we adopt the SITC Revision 2 data. The SITC Revision 2, though its classification in precision machinery is not detailed enough, adopts a more detailed commodity classification particularly in the machinery and transport goods than that of the SITC Revision 1 and hence is suitable for our analysis. To satisfy the third condition, we make use of the data from 1987.

We classify items into final goods or parts and components according to the following criteria. The items that include a word such as “parts” or “accessories” in their descriptions or that are not supposed to be classified as consumption goods or investment goods are classified into parts and components (e.g., engines of automobiles). We define “final goods” as a complement of parts and components in the whole machinery goods. Accordingly, our “final goods” inevitably include some intermediate goods when the classification of goods concerned is not detailed enough.

The codes classified as parts and components are listed in the following box, and the rest in code 7, 82, 87, 88, and 89 are classified as final goods.

7119,71319,71331,71332,7139,7149,7169,71889,72119,72129,72139,72198,72199,7239,72449,72469,72479,7259,72689,7269,72719,72729,72819,72839,72849,7369,73719,73729,74149,7429,7439,74419,7449,74519,74523,74999,759,764,77129,772,77579,77589,77689,77819,77829,77889,784,78539,78689,79199,7929,82119,82199,87429,88119,88121,88129,88411,88529,89949

Appendix 2. Countries in the sample and regional definition

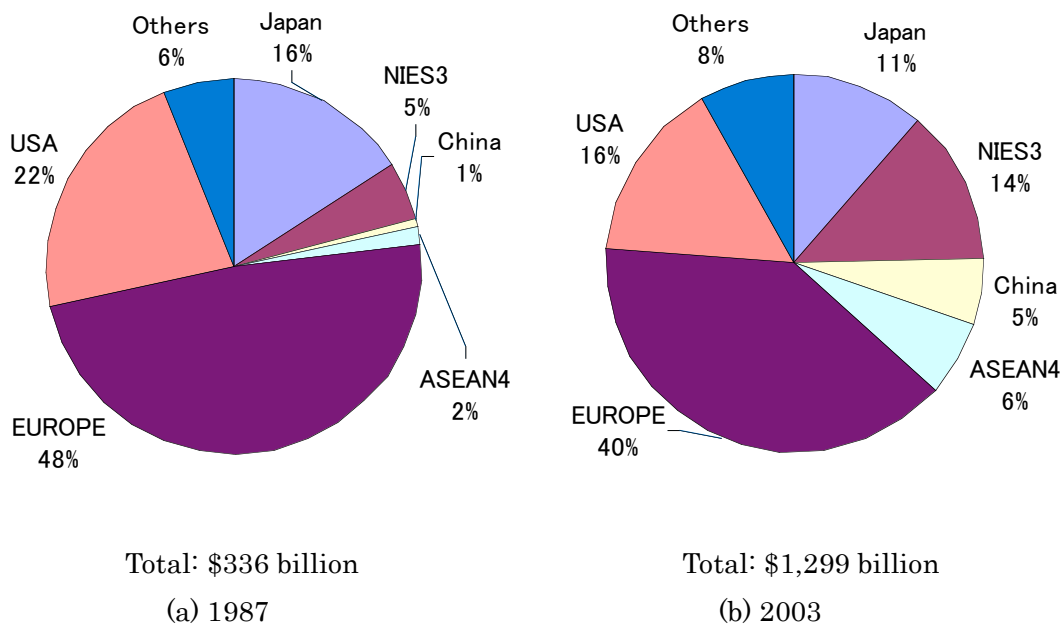
East Asia (9)	Japan	Japan
	NIES3	Hong Kong SAR, Rep. of Korea, Singapore
	ASEAN4	Indonesia, Malaysia, Philippines, Thailand
	China	China
Europe (18)	Northern Europe	Finland, Ireland, Norway, Sweden
	Western Europe	

		Austria, Belgium–Luxembourg, Denmark, France, Germany, Greece, Italy, Netherlands, Portugal, Spain, Switzerland, United Kingdom
	Eastern Europe	Czechoslovakia, Poland
USA (1)		USA
Others (28)		Algeria, Argentina, Australia, Bolivia, Brazil, Cameroon, Canada, Chile, Colombia, Costa Rica, Cote d'Ivoire, Ecuador, Egypt, India, Israel, Kenya, Mexico, Morocco, New Zealand, Pakistan, Panama, Peru, Saudi Arabia, Sri Lanka, Tunisia, Turkey, Uruguay, Venezuela

Appendix 3. Definition and Source of Data

Variable	Definition	Source
EX	i 's Export to j (US \$)	Authors' calculation, based on UN Comtrade.
DIS	Distance between capital cities of i and j (km)	Fitzpatrick and Modlin (1986).
EXGDP	GDP of country i (US \$ million)	World Development Indicator
EXPERGDP	Per capita GDP of country i (US \$)	World Development Indicator
IMGDP	GDP of country j (US \$ million)	World Development Indicator
IMPERGDP	Per capita GDP of country i (US \$)	World Development Indicator
GAP	the absolute value of the difference in per capita GDP of i and j	Authors' calculation
ADJ	Adjacency dummy	1 if both countries have a common national border, 0 otherwise.
LAN	Common language dummy	1 if both countries use at least one common language, 0 otherwise.
Europe Dummy	Intra-regional trade in Europe	1 if both countries are European countries, 0 otherwise.
East Asia Dummy	Intra-regional trade in East Asia	1 if both countries are East Asian countries, 0 otherwise.

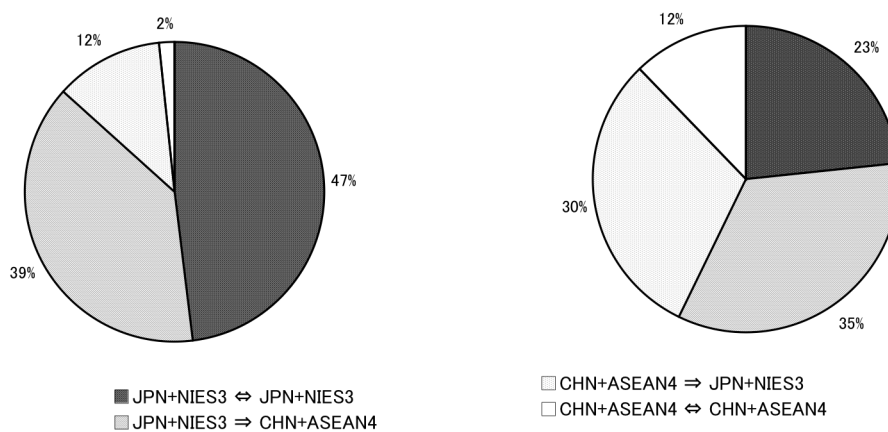
Figure 1. The share of machinery parts and components exports by countries/regions



Note: As for the definition of regions, see Appendix 2.

Data source: UN Comtrade online

Figure 2. Intra-regional machinery parts and components trade in East Asia



Total: \$23 billion

(a) 1987

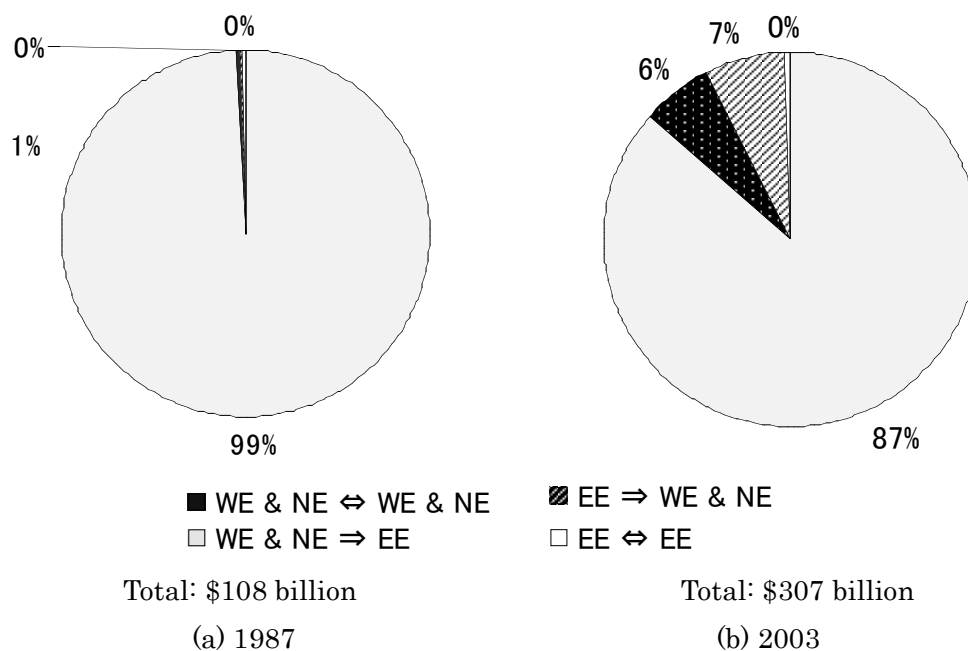
Total: \$248 billion

(b) 2003

Note: As for the definition of regions, see Appendix 2.

Data source: UN Comtrade online

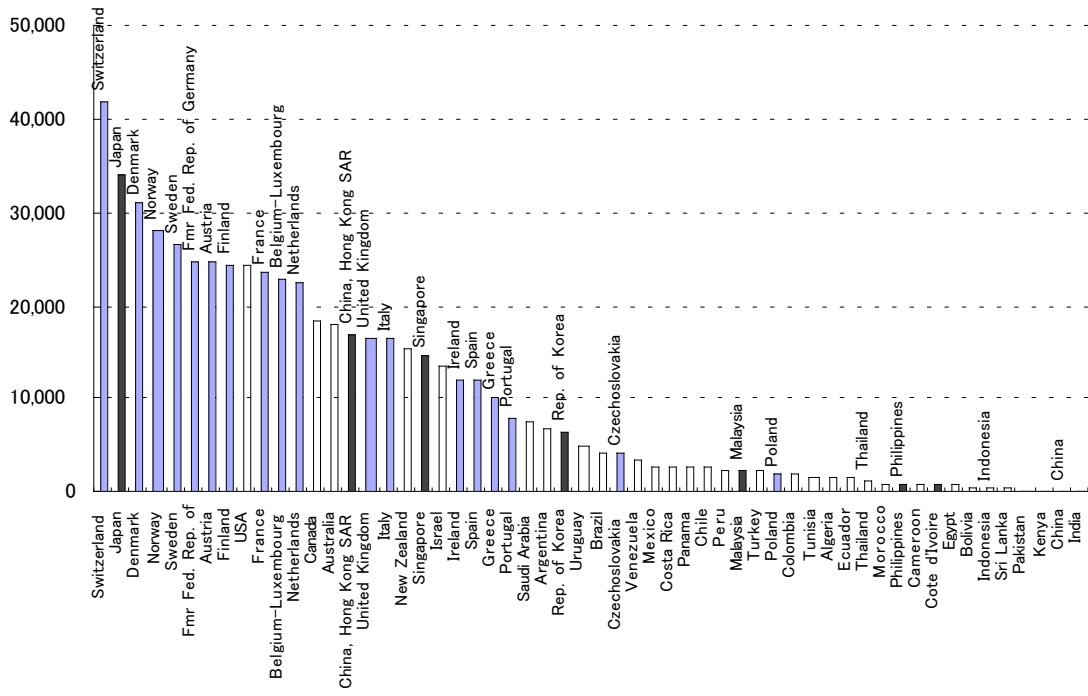
Figure 3. Intra-regional machinery parts and components trade in Europe



Note: WE, NE and EE mean Western Europe, Northern Europe, and Eastern Europe, respectively. As for the more detailed regional definition, see Appendix 2.

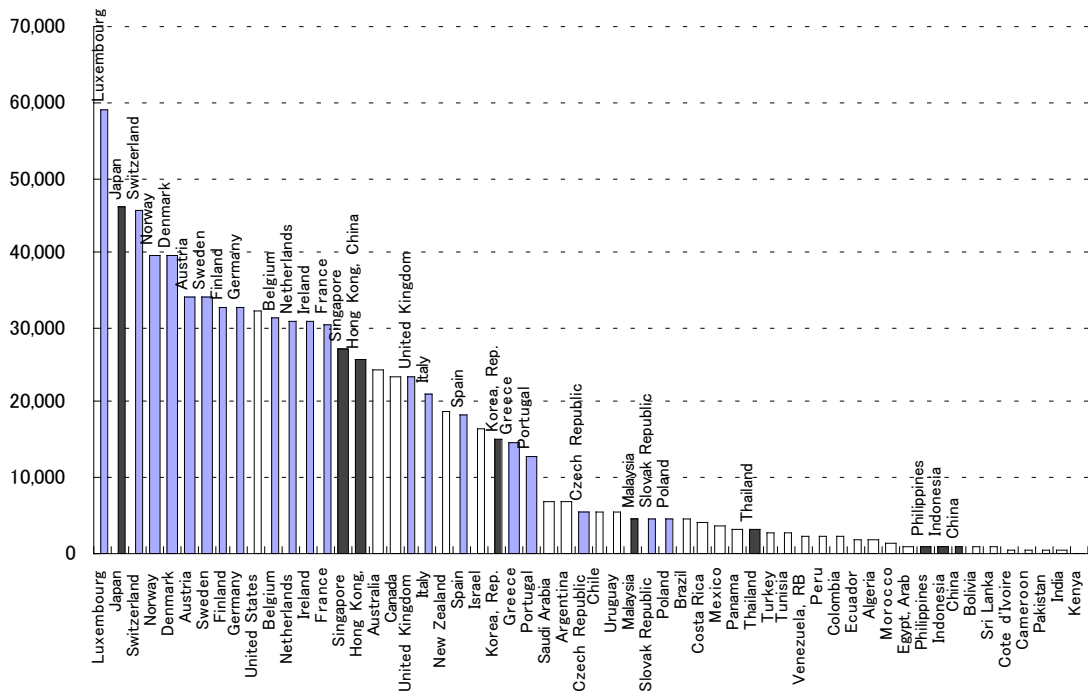
Data source: UN Comtrade online

Figure 4. Ranking of per capita GDP in 1987 (\$)



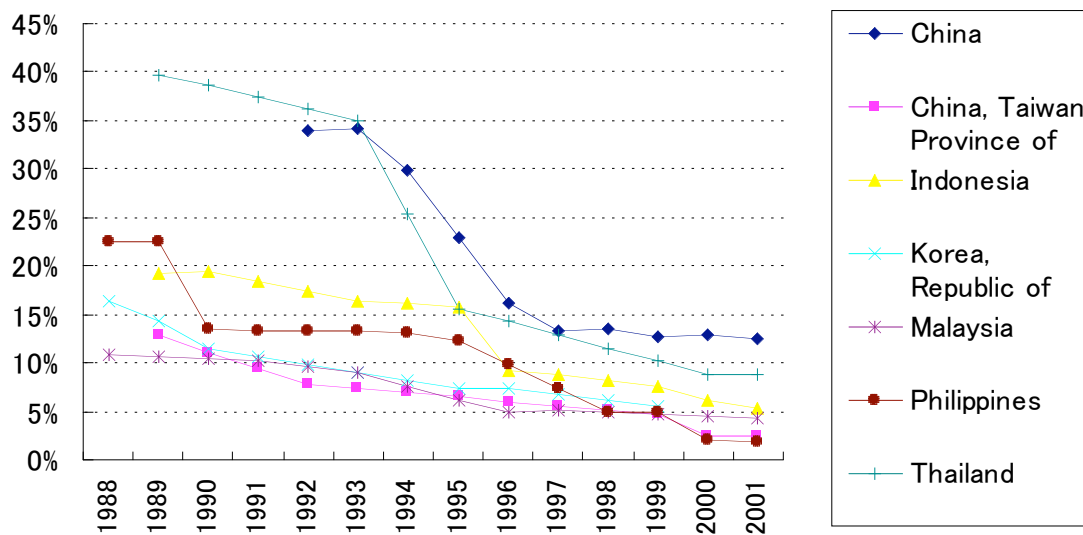
Data source: World Bank, World Development Indicator

Figure 5. Ranking of per capita GDP in 2003 (\$)



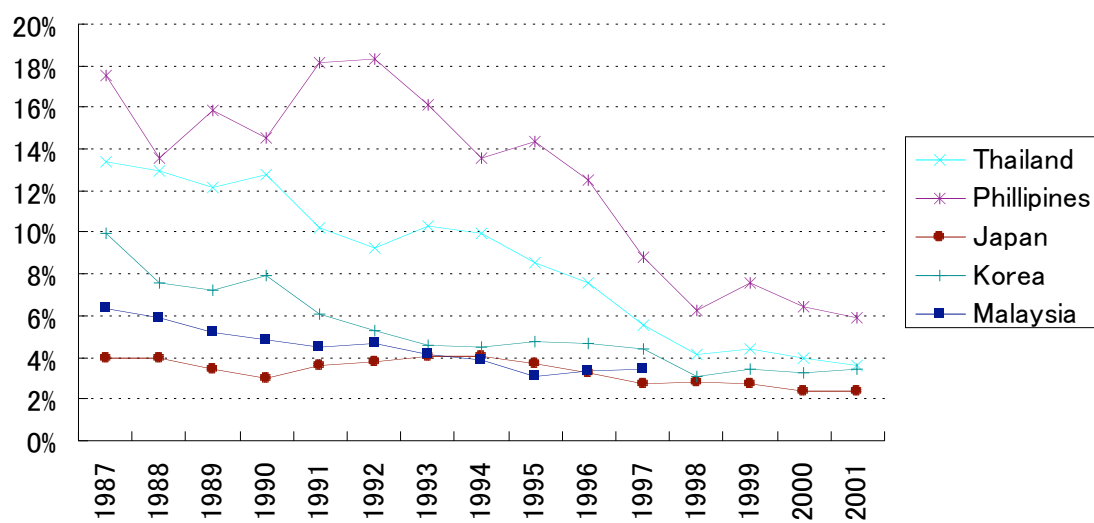
Data source: World Bank, World Development Indicator

Figure 6. Trade-weighted average of MFN rate (machinery and transport equipment)



Data source: UNCTAD, Handbook of Statistics CDROM

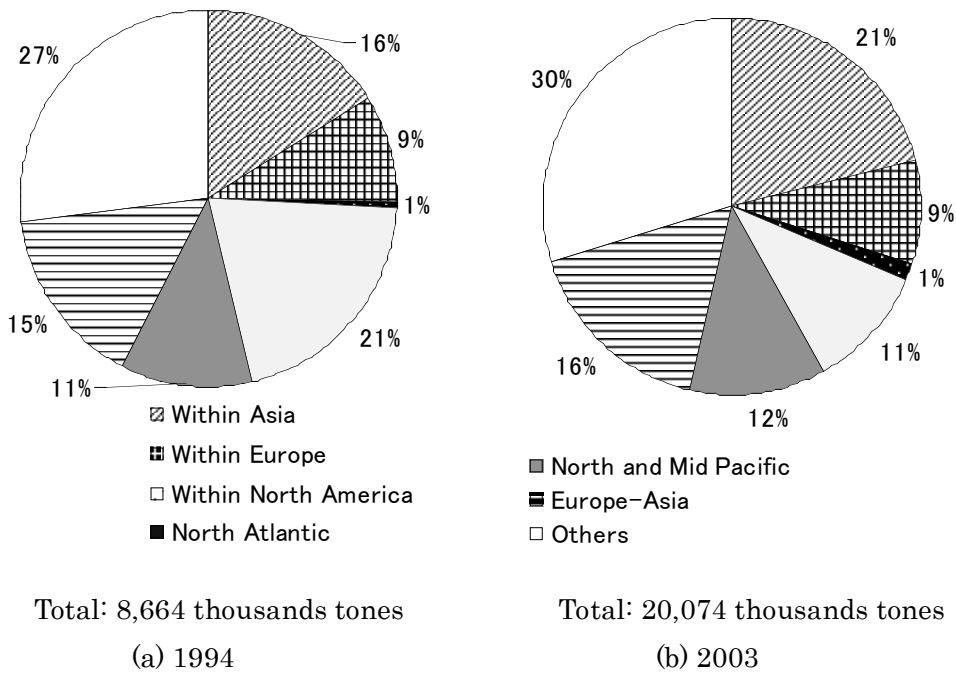
Figure 7. Tariff burden rate



Note: A tariff burden rate is the ratio of taxes-international trade (import duties) to import values.

Data source: OECD, Revenue Statistics; IMF, Government Finance Statistics Yearbook; IMF, International Finance Statistics Yearbook

Figure 8. Regional freight tones by route area



Note: These graphs cover only members of the International Air Transport Association (IATA). Notice that the definition of regions here is based on the IATA. The flow within region does not include domestic flows.

Source: IATA, World Air Transport Statistics

Table 1. Changes in machinery exports: 1987–2003

(billions of dollars)

<u>World</u>						
	Total	Machinery	Final	Parts	Parts/Total	Parts/Machinery
1987	2,127	837	502	336	16%	40%
2003	6,526	2,913	1,613	1,299	20%	45%
Changes	207%	248%	222%	287%		
<u>East Asia</u>						
	Total	Machinery	Final	Parts	Parts/Total	Parts/Machinery
1987	445	230	152	77	17%	34%
2003	1,759	996	518	478	27%	48%
Changes	295%	334%	241%	516%		
<u>Europe</u>						
	Total	Machinery	Final	Parts	Parts/Total	Parts/Machinery
1987	1,168	440	276	163	14%	37%
2003	3,116	1,292	780	513	16%	40%
Changes	167%	194%	182%	214%		

- Note:
1. The values in World, East Asia, and Europe are calculated using the sum of exports of all sample countries, the sum of exports of all East Asian countries, and the sum of exports of all European countries, respectively.
 2. As for the definition of regions, see Appendix 2.
 3. Total, Machinery, Final, and Parts stand for all commodities, machinery goods, final machinery goods, and machinery parts and components, respectively.

Source: UN Comtrade online

Table 2. Changes in intra-regional machinery exports: 1987–2003

(billions of dollars)

East Asia

	Final			Parts		
	World	Regional	Regional/World	World	Regional	Regional/World
1987	152	22	14%	77	23	30%
2003	518	153	30%	478	252	53%
Changes	241%	596%		516%	1000%	

Europe

	Final			Parts		
	World	Regional	Regional/World	World	Regional	Regional/World
1987	276	162	59%	163	108	66%
2003	780	449	58%	513	307	60%
Changes	182%	178%		214%	185%	

- Note:
1. World and Regional correspond the value of exports to the whole world and of exports within the region, respectively.
 2. As for the definition of regions, see Appendix 2.
 3. Final and Parts denote final machinery goods and machinery parts and components, respectively.

Source: UN Comtrade online

Table 3. Estimation results of full sample regressions

Machinery final goods	1987		1995		2003	
	(1)	(2)	(1)	(2)	(1)	(2)
Distance	-1.75** (0.13)	-1.66** (0.13)	-1.39** (0.11)	-1.28** (0.12)	-1.31** (0.10)	-1.24** (0.10)
Exporter_GDP	1.91** (0.06)	2.36** (0.05)	1.99** (0.06)	2.36** (0.05)	1.90** (0.05)	2.20** (0.04)
Importer_GDP	1.03** (0.06)	1.11** (0.05)	1.08** (0.06)	1.24** (0.05)	1.02** (0.05)	1.10** (0.04)
Exporter_per capita GDP	1.24** (0.07)		0.93** (0.06)		0.76** (0.05)	
Importer_per capita GDP	0.49** (0.07)		0.51** (0.07)		0.34** (0.06)	
Gap		0.61** (0.06)		0.39** (0.06)		0.37** (0.05)
East Asia Dummy	2.86** (0.55)	2.08** (0.57)	2.56** (0.27)	2.16** (0.29)	2.33** (0.28)	2.07** (0.28)
Europe Dummy	-0.70* (0.38)	1.18** (0.38)	-0.90** (0.27)	0.75** (0.26)	-0.72** (0.23)	0.67** (0.22)
Language	1.91** (0.28)	2.77** (0.29)	1.88** (0.22)	2.39** (0.23)	1.42** (0.19)	1.83** (0.20)
constant	-62.42** (2.18)	-67.41** (2.22)	-65.54** (2.01)	-71.34** (2.02)	-58.99** (1.79)	-63.41** (1.82)
observations	3,080	3,080	3,080	3,080	3,080	3,080
Adj. R-squared	0.588	0.559	0.596	0.571	0.631	0.614

Machinery parts and components	1987		1995		2003	
	(1)	(2)	(1)	(2)	(1)	(2)
Distance	-1.79** (0.12)	-1.71** (0.13)	-1.64** (0.11)	-1.53** (0.11)	-1.36** (0.10)	-1.28** (0.10)
Exporter_GDP	1.98** (0.06)	2.42** (0.05)	2.03** (0.05)	2.36** (0.05)	1.86** (0.05)	2.14** (0.04)
Importer_GDP	1.33** (0.06)	1.39** (0.05)	1.18** (0.05)	1.37** (0.05)	1.19** (0.05)	1.29** (0.04)
Exporter_per capita GDP	1.15** (0.07)		0.87** (0.06)		0.72** (0.05)	
Importer_per capita GDP	0.42** (0.07)		0.59** (0.06)		0.37** (0.06)	
Gap		0.53** (0.06)		0.43** (0.06)		0.37** (0.05)
East Asia Dummy	3.42** (0.54)	2.71** (0.55)	3.04** (0.29)	2.64** (0.32)	3.11** (0.29)	2.86** (0.30)
Europe Dummy	-1.48** (0.38)	0.21 (0.37)	-1.42** (0.25)	0.25 (0.24)	-1.05** (0.24)	0.32 (0.22)
Language	2.24** (0.28)	3.02** (0.28)	2.00** (0.21)	2.50** (0.23)	1.58** (0.19)	2.00** (0.20)
constant	-70.70** (2.13)	-75.30** (2.17)	-67.44** (1.91)	-73.22** (1.92)	-62.35** (1.75)	-66.70** (1.77)
observations	3,080	3,080	3,080	3,080	3,080	3,080
Adj. R-squared	0.610	0.585	0.635	0.613	0.637	0.622
Wald test (p-value)	0.000	0.000	0.002	0.000	0.000	0.000

Note: Dependent variables in the upper table and in the lower table are trade value in final goods and in parts and components, respectively. The definition of independent variables are reported in Appendix 3. Heteroskedasticity-consistent standard errors (White) are in parentheses. ** and * show 1% and 5% significant, respectively. The null hypothesis in the Wald test is that all coefficients are identical between final goods equation and parts equation.

Table 4. Estimation results for machinery parts and components: East Asia

	1987		1995		2003	
	(1)	(2)	(1)	(2)	(1)	(2)
Distance	-0.45 (0.28)	-0.42 (0.41)	-0.70** (0.15)	-0.66** (0.23)	-0.64** (0.17)	-0.63** (0.19)
Exporter_GDP	0.56** (0.14)	0.53** (0.20)	0.68** (0.09)	0.67** (0.12)	0.69** (0.09)	0.69** (0.10)
Importer_GDP	-0.02 (0.18)	-0.13 (0.22)	0.18 (0.10)	0.17 (0.13)	0.42** (0.11)	0.46** (0.11)
Exporter_per capita GDP	0.87** (0.13)		0.56** (0.07)		0.10 (0.08)	
Importer_per capita GDP	0.64** (0.15)		0.57** (0.07)		0.24* (0.09)	
Gap		0.89** (0.22)		0.50** (0.12)		0.12 (0.10)
Language	1.26* (0.52)	0.99 (0.61)	1.16** (0.29)	1.07* (0.45)	1.63** (0.25)	1.65** (0.28)
constant	-5.40 (6.10)	2.57 (7.72)	-6.86 (3.99)	-1.51 (4.75)	-6.73 (3.75)	-6.02 (3.84)
observations	72	72	72	72	72	72
Adj. R-squared	0.766	0.661	0.743	0.536	0.553	0.517
Wald test (p-value)	0.006	0.008	0.000	0.000	0.000	0.000

Note: Dependent variables are trade value in parts and components. The definition of independent variables are reported in Appendix 3. Heteroskedasticity-consistent standard errors (White) are in parentheses. ** and * show 1% and 5% significant, respectively. The null hypothesis in the Wald test is that all coefficients are identical between final goods equation (unreported) and parts equation.

Table 5. Estimation results for machinery parts and components: Europe

	1987		1995		2003	
	(1)	(2)	(1)	(2)	(1)	(2)
Distance	-1.13** (0.28)	-1.13** (0.28)	-1.15** (0.10)	-1.12** (0.09)	-1.27** (0.10)	-1.25** (0.11)
Exporter_GDP	1.35** (0.13)	1.47** (0.13)	1.07** (0.05)	1.16** (0.05)	1.07** (0.05)	1.02** (0.05)
Importer_GDP	1.24** (0.16)	1.66** (0.22)	0.89** (0.05)	0.86** (0.05)	0.92** (0.06)	0.86** (0.06)
Exporter_per capita GDP	0.50* (0.21)		0.44** (0.07)		-0.22* (0.10)	
Importer_per capita GDP	1.48** (0.37)		-0.04 (0.09)		-0.27* (0.10)	
Gap		-0.16 (0.10)		-0.14* (0.06)		-0.04 (0.04)
Language	-0.07 (0.43)	0.58 (0.40)	-0.36 (0.20)	0.22 (0.19)	-0.36 (0.20)	-0.55 (0.18)
constant	-61.65** (9.17)	-55.21** (8.94)	-28.94** (2.13)	-25.41** (2.27)	-19.54** (2.47)	-21.32** (2.41)
observations	306	306	306	306	306	306
Adj. R-squared	0.562	0.505	0.802	0.790	0.720	0.711
Wald test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Note: Dependent variables are trade value in parts and components. The definition of independent variables are reported in Appendix 3. Heteroskedasticity-consistent standard errors (White) are in parentheses. ** and * show 1% and 5% significant, respectively. The null hypothesis in the Wald test is that all coefficients are identical between final goods equation (unreported) and parts equation.