

Trade Integration and Production Network in East Asia

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Abstract

In recent decades, the intensification of intra-regional trade within East Asia has been driven by the rapid expansion of parts and components trade notably from machinery sector and electrical machinery sub-sector. This paper examines the patterns of intra- trade in machinery sector and the linkage between parts and components trade and the regional production/ distribution network led by multinational enterprises. Using international trade data and survey results on business operations of Japanese MNEs and their overseas affiliates, we found that trade patterns in East Asia has shifted towards parts and components trade. Redirection of trade flows has also been observed among East Asian countries especially for Japan and China. An investigation into micro data of Japanese MNEs reveals that parts and components trade is highly associated with fragmentation of production and back-and-forth transactions between parent companies and their affiliates located in different countries according to location advantages. Despite the highly integrated trade, East Asia has still relied on final demand outside the region. The paper suggests that it is crucial for East Asia to maintain its competitive position in the world market. The region could do so by further strengthening the regional production network and achieving deeper cooperation.

Executive Summary

Intra-regional trade to East Asia (which includes Japan, China, Hong Kong, South Korea, Singapore, Malaysia, Philippines, Thailand, and Indonesia) has been rising significantly in the last few decades and it now accounts for almost half of the total East Asian exports. An important question for East Asia is to understand the factors underpinning the rapid expansion of trade within the region and how the region should pursue further policies so as to gain the most benefits from the intensified trade integration.

Along with the rising share of intra-regional trade, the decomposition of commodity structure reveals that East Asian trade has shifted from agricultural and labor-intensive commodities towards more sophisticated and higher value-added products in machinery sector particularly for electronics and electrical equipment. A closer investigation into intra-machinery trade in East Asia shows that parts and components trade has grown faster than final product trade in machinery sector.

An explosive trade in parts and components has been shared across most economies in East Asia. For the region as a whole, parts and components represent more than half of exports and two-thirds of imports. Among members of East Asia, China has been rising as a major player in parts and components trade within the region while Japan has been declining its role as a regional exporter. The driving forces behind the high and rising degree of intra-regional parts and components trade is the fragmentation of production in the vertical supply chains with production being relocated in different countries according to location advantages. Production fragmentation/distribution network in East Asia has been known to be far more developed than similar networks in other regions.

The study finds that trade in parts and components within East Asia has a close link with the production sharing led by multinational enterprises. The sales/ purchases transactions of East Asian affiliates are large with Japan and the share of transactions with other East Asian countries has increased, suggesting the extensiveness of the network. Quantitative analysis of trade integration in East Asia further reveals that parts and components trade in electrical machinery sector has risen significantly during 2001-2005 compared to 1996-2000 while final good trade has declined. Being East Asia insiders is also found to be important for parts and components trade.

From the policymaker's point of view, international production fragmentation has played a vital role in intra-regional trade dynamism in East Asia. Given the region's dependence on extra-regional demand, East Asia needs to maintain its competitive position in the global market. To achieve such goal, East Asia can further strengthen the regional production network to sustain the Asian vitality in the longer term. For developing East Asia, several policy measures should be pursued further to enhance location advantages, to facilitate MNEs business investment and operations, and to decrease the service link costs.

1. Introduction

East Asia¹ countries have achieved high economic growth mainly from trade openness and outward-oriented strategies for the last four decades. Japan first emerged as a regional exporter in 1960s followed by Hong Kong, South Korea, Singapore, and Taiwan in 1970s. Export-led growth strategies have been developed along with the moving up of the product ladders by changing the export structure from basic commodities to capital intensive products². Since 1980s, developing East Asia undergone a shift from labor-intensive commodities to high technology products as witnessed in the decline in exports of textile and agriculture products together with the sharp increase in exports of machinery products. In addition to expansion of international trade, intra-regional trade in East Asia has also been increasingly expanded in the last decade. Currently, about half of trade (export plus import) in East Asia is conducted inside the region.

What has been the driving force of the extensive trade integration in the region? The explosive growth in East Asia's parts and components trade has been shared across most countries in the region and has also been documented widely in recent studies. A high and rising degree of intra-regional trade in parts and components has been associated with the fragmentation of vertical supply chains within production networks where parts and components are produced and assembled into final goods within Asia, particularly in East and Southeast Asia³. These production networks were initiated in the mid 1980s after the Plaza Accord, and their development accelerated when developing East Asian economies started imposing more favorable policies to attract foreign investment. Despite the significant volume of trade in parts and components, the ultimate destination for most final assembled products of East Asia remains markets outside the region especially in Europe and the US.

Since the mid 1980s, Japan has been the most important source of FDI in developing East Asia. Japanese multinational enterprises (MNEs) have played a significant role in setting up the production and distribution network, which has shaped patterns of trade flows in the region. The trade-FDI nexus has become a powerful driver of integration in East Asia. China has been a new comer in the production network and an attractive FDI destination. Share of China trade to total East Asian trade and its participation in the regional network have increased sharply and China has become an important export and markets for other developing East Asia.

This paper represents an attempt to shed some lights on the two main issues. First, to what extent has the intra-machinery trade in East Asia changed in the recent decades? We will emphasize on the development in machinery sector where parts and components trade has played a dominant role. Second, what are forces driving the intensified trade integration in this sector? We will explore the linkage between trade in parts and components and the regional production/distribution network particularly

¹ In this study, East Asia includes Japan, China, Hong Kong, South Korea, Singapore, Malaysia, Philippines, Thailand, and Indonesia.

² See Gill and Kharas (2007).

³ See Asian Development Outlook (2006).

in electrical machinery sub-sector. Analysis of China's participation in the intra-regional trade will be made throughout the paper though issue of China's crowding out effect on other developing Asia is beyond the scope of this paper.

The paper is organized as follows. In section 2, we begin our analysis with an overview of intra-trade in machinery sector within East Asia. In section 3, the linkage between machinery parts and components trade and production fragmentation will be explored using both macro data and micro data obtained from available business surveys. In section 4, gravity model of trade integration will be used to test the intra-trade in electrical machinery sector in East Asia with a focus on parts and components trade versus finished good trade. In section 5, we will discuss policy issues for East Asia drawn from our study. Finally, section 6 provides our concluding remarks.

2. Intra-trade in Machinery Sector in East Asia

In the past few decades, many countries in East Asia achieved high economic growth from increased trade openness and outward-oriented strategies. Particularly, rapid growth in East Asia has been driven by remarkable expansion of intra-regional trade since the 1990s. The share of intra-regional trade in total exports rose sharply from 32.0 percent in 1985 to 45.4 percent in 2005. For import side, the intra-regional trade share increased from 36.4 percent in 1985 to 48.5 percent of total imports in 2005.

2.1 The rise of Machinery Sector

A close examination of trade by product category reveals that the main driver of the intensified intra-regional trade in East Asia has been the shift of commodity structure in both exports and imports. The rise in some certain segments especially machinery and electrical machinery sub-sector has made such a major contribution (Pootrakool et.al, 2003).

The change in export composition in East Asia from 1990-1995 to 2000-2005 is shown in table 2.1a. The region has decreased its trade share in agriculture and labor-intensive textiles products. In contrast, machinery and transport equipment sector has become a major export commodity accounting for about half of the total regional exports. Within this sector, electrical machinery (including apparatus and appliances) has increased dramatically particularly for China, and ASEAN-4. Japan has a decline in the export share of machinery and transport equipment but a rise in import share in this category by about 10 percent. For Thailand, the share of agriculture products and textiles trade has declined sharply. In contrast, share of machinery and transport equipment rose significantly from 28 percent to 44 percent with a significant increase in electrical machinery and appliances for both exports and imports.

Table 2.1a: The Commodity Composition of Foreign Trade in East Asia (% of Total Trade)

	East Asia		ASEAN-4		China		Japan		Thailand	
	1990-1995	2000-2005	1990-1995	2000-2005	1990-1995	2000-2005	1990-1995	2000-2005	1990-1995	2000-2005
Export										
Agriculture&Crude Material (excl. fuels)	5.6	4.2	17.6	8.3	8.5	5.6	1.2	1.4	29.0	18.3
Fuel and Lubricants	3.9	3.8	12.9	7.9	2.8	2.7	0.5	0.4	0.9	3.2
Chemical and Related Products	4.8	6.6	2.3	3.8	3.6	4.7	5.8	8.1	2.9	6.6
Manufactured Goods	12.7	12.3	12.6	8.1	13.0	16.6	11.3	10.4	12.2	11.9
- Textiles Yarn & Fabrics	4.0	3.6	3.2	1.8	6.5	6.0	1.9	1.4	3.8	2.7
Machinery and Transport Equipment	47.4	53.7	25.4	35.9	11.9	40.3	71.2	66.6	28.2	43.5
- Office Machines	7.2	10.6	4.4	10.0	1.4	11.8	8.8	5.7	8.0	11.1
- Telecommunication equipment	7.8	8.8	7.0	5.6	3.5	10.1	8.6	6.1	5.5	5.8
- Electrical Machinery & Appliances	11.2	16.4	9.9	15.5	3.2	9.8	13.1	15.0	8.9	14.5
Import										
Agriculture&Crude Material (excl. fuels)	14.8	10.9	10.3	9.2	6.8	10.9	27.0	17.9	10.2	7.9
Fuel and Lubricants	11.7	13.3	6.8	11.4	2.9	8.0	20.7	21.5	7.9	13.2
Chemical and Related Products	7.7	8.8	10.1	10.0	7.8	12.5	7.1	7.4	10.3	10.9
Manufactured Goods	14.2	12.3	16.8	13.0	16.2	15.5	11.7	8.9	20.2	17.4
- Textiles Yarn & Fabrics	3.5	2.6	3.0	2.0	5.5	4.0	1.8	1.3	2.6	2.2
Machinery and Transport Equipment	30.5	41.3	45.5	48.5	27.6	44.5	17.7	27.3	43.7	42.8
- Office Machines	3.2	6.7	2.6	6.0	1.2	5.4	3.1	6.4	3.9	5.7
- Telecommunication equipment	3.8	5.2	3.7	3.7	3.5	4.9	1.8	3.6	3.3	3.7
- Electrical Machinery & Appliances	8.6	17.7	13.3	24.4	4.3	18.5	4.4	8.7	10.6	17.3

Source: UN Comtrade online

Besides the rising number of trade share, machinery sector and electrical machinery sub-sector have grown dramatically during the last decade. Under broad category of the Harmonized System code, machinery goods (HS 85-92) account for almost 60 percent of East Asian exports. In Table 2.1b shows the compounded annual growth rates of East Asia trade between 1995 and 2004. The table indicates that East Asia experienced a decline in trade of labor-intensive products such as apparel, textiles, and footwear. On the other hand, significant growth is observed in machinery sector, particularly in electronics and electrical machinery during the same period. China has a striking double-digit growth for all products in machinery sector while still having a strong growth in many other labor-intensive industries. This can be described as a unique role of China as a world production base. We will examine this issue later in the paper.

For East Asia as a whole, the share of electrical machinery to total machinery rose from 42 percent in 1996 to 45 percent in 2005 for exports, and from 43 percent in 1996 to 53 percent in 2005 for imports. Non-electrical machinery sector (HS84) and precision machinery (HS90) have also increased their shares but the magnitude was far below the expansion in electrical machinery sector. See Appendix Table A.3 for more details.

Table 2.1b: Growth in Trade by HS category,1995-2004

HS code	commodity	Exports				Imports			
		Japan	China	NIEs	ASEAN-5	Japan	China	NIEs	ASEAN-5
01-05	Live animals	5.2	7.5	-5.8	2.1	-2.0	11.5	2.5	4.6
06-10	Unprocessed fruit and vegetable products	1.3	7.7	-4.2	2.7	0.6	0.2	-0.4	1.3
11-24	Food, beverages, and Tobacco	1.9	2.8	-3.3	5.9	0.4	9.3	-1.7	3.9
25-26	Mineral products incl. cement	12.9	14.8	0.7	6.3	3.3	22.4	6.1	3.0
27	Mineral fuels incl. petroleum and coal	0.8	12.7	11.6	8.2	7.0	25.3	9.7	9.8
28-38	Chemicals and allied industries	6.1	12.9	8.9	13.1	4.7	13.4	4.2	4.4
39-40	Plastic and rubber products	3.7	20.5	4.1	4.3	2.4	14.9	1.2	4.4
41-43	Leather products	-2.9	13.7	2.4	0.0	-1.9	8.5	1.1	0.3
44-46	Wood and cork	0.2	16.4	-5.4	-2.0	-2.9	8.7	-4.3	1.9
47-49	Pulp and paper	2.9	14.2	1.7	8.8	-2.5	10.4	-2.9	1.4
50-60	Textiles	0.2	9.9	-1.1	2.2	-3.5	3.2	-2.7	0.7
61-63	Apparel	2.6	12.2	0.5	4.0	2.6	9.0	5.3	6.7
64-67	Footwear, headgear, and umbrellas	-9.6	10.9	-4.9	3.8	0.4	13.1	3.7	8.2
68-70	Articles of stone, glass and ceramic products	1.6	14.0	1.0	7.7	3.7	11.3	3.6	-1.1
71	Gems and jewelry	5.0	12.0	12.0	-1.5	-8.0	26.6	6.6	0.8
72-83	Base metals	3.6	16.7	5.7	10.1	2.2	13.8	4.6	2.3
84	Nonelectrical Machinery	1.6	34.1	6.2	12.9	6.7	13.8	5.5	1.5
85	Electronics and Electrical Machinery	2.3	25.8	9.8	8.2	7.3	21.4	7.6	5.6
86-89	Transportation machinery	5.0	21.8	10.9	9.6	2.4	13.2	-0.4	-1.3
90-91	Precision instruments	4.7	18.8	9.0	10.7	6.5	23.4	7.9	4.9
92	Musical Instruments	3.2	14.3	10.2	8.9	5.1	19.6	1.3	1.1
93	Arms and ammunition	1.6	-11.8	9.3	-8.1	0.3	5.6	-0.3	22.3
94-97	Miscellaneous manufactures	2.3	15.7	0.8	5.3	3.2	8.0	3.3	3.2
	All sectors	3.6	17.7	6.5	7.7	3.9	14.8	5.2	3.6

Source: Asian Development Outlook (2007)

The original data are obtained from Statistic Canada, World Trade Analyzer.

Note: All figures are compounded annual growth rates between 1995 and 2004.

NIEs include Hong Kong SAR, South Korea, Singapore, and Taiwan.

ASEAN-5 includes Indonesia, Malaysia, Philippines, Thailand, and Vietnam.

Remarkable increase in intra-regional trade also implies that East Asia has had a progress in the diversification of its export and import markets. Further analysis of East Asia's machinery trade indicates that the region has shifted its trade with Europe and the US towards more intra-regional trade as shown in Table 2.1c. For each region, the first two columns represent an individual country's share of machinery trade (exports plus imports) with corresponding region to its total machinery trade in 1996 and in 2005. The third column represents the difference of the share in 2005 from 1996 level. Most countries in East Asia have had more trade within the region especially for Hong Kong SAR, Japan, Indonesia, and Philippines during the last decade. On the other hand, almost all East Asian countries experienced a decline in the trade share with EU-15 and NAFTA in 2005 from the 1996 level. For China, a small increase in the share of intra-trade is a mixed result of change in geographic composition of its exports and imports. China has relied more on imports from other East Asian countries and less on imports from other regions. For export side, China exports to other East Asian members decline while its exports to other regions increase. Between 1996 and 2005, China's share of exports rose from 14 to 19 percent for EU and from 22 to 24 percent for NAFTA. These observations indicate that the regional trade has also benefited from the role of China as a platform for regional exports to the world market.

Table 2.1c : Intra-regional Trade in Machinery Sector within East Asia

	Trade with EA (Intra-regional)			Trade with EU-15			Trade with NAFTA		
	% of total trade		changes	% of total trade		changes	% of total trade		changes
	1996	2005		1996	2005		1996	2005	
China	43.8	44.4	0.6	23.2	16.5	-6.6	17.3	16.5	-0.8
Hong kong	57.5	68.9	11.3	16.1	11.7	-4.3	14.5	8.9	-5.6
Indonesia	46.4	60.2	13.9	28.0	16.5	-11.5	15.1	12.5	-2.6
Japan	32.2	46.5	14.3	18.8	15.2	-3.6	34.4	27.2	-7.3
Malaysia	50.2	48.1	-2.1	40.0	33.3	-6.7	29.7	24.2	-5.5
Philippines	52.7	66.6	13.9	10.4	13.7	3.3	19.0	20.4	1.3
Singapore	55.1	65.0	9.9	14.5	11.0	-3.5	22.5	14.9	-7.6
South Korea	38.5	47.1	8.6	16.7	16.5	-0.2	27.7	18.9	-8.8
Thailand	54.7	58.8	4.1	16.3	12.5	-3.9	17.4	12.9	-4.4
East Asia (EA)	43.9	52.2	8.2	19.5	15.8	-3.7	25.8	18.4	-7.5

Source: Author's calculation based on the UN Comtrade online

Note: In this table, trade refers to exports plus imports.

Beside the rapid expansion in intra-machinery industry trade, trade in machinery parts and components⁴ within East Asia has become an important characteristic of East Asian trade. From 1990 to 2005, the share of machinery parts and components exports within East Asia grew from 5.7 percent to 17.3 percent. In a global context, an explosive expansion of trade in machinery parts and components has also been clearly observed. East Asia's share of parts and components in total exports rose from around 36 percent in 1990 to 52 percent in 2005. In 2005, almost 70 percent of regional machinery imports were parts and components, rising sharply from around 50 percent in 1990.

The significance of parts and components in total machinery trade has been rising quite rapidly. Table 2.2a tabulates trade of machinery goods, dividing into finished products and parts, along with the development in parts and components trade in East Asia from 1990 to 2005. The share of parts to total machinery exports rose sharply from 36 percent to 52 percent while the similar share for imports grew significantly from 49 to 67 percent during the period. See Table A.1 in Appendix for more details.

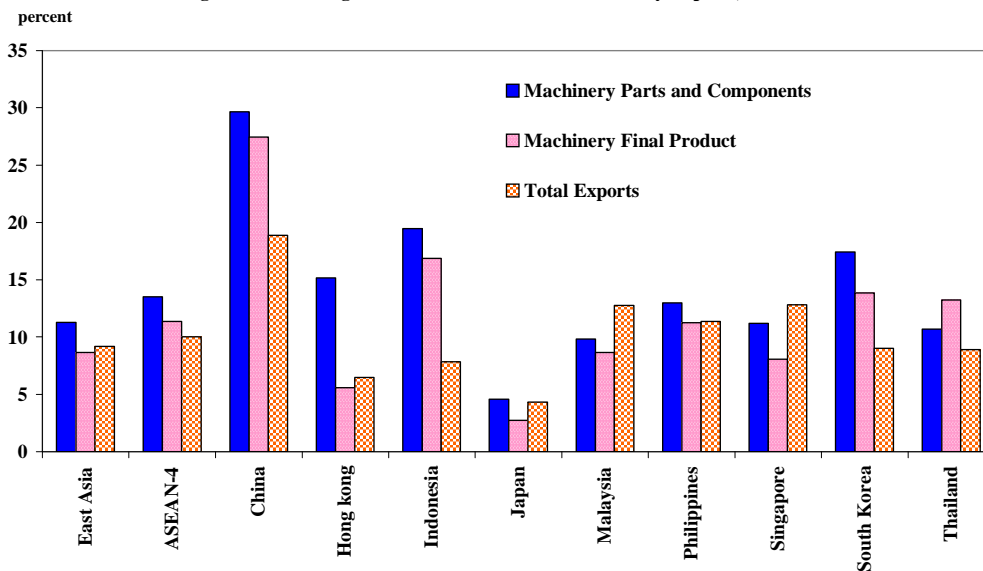
⁴ The definition of machinery parts and components used in this paper are obtained from Ando and Kimura (2007). Details are in the Appendix.

Table 2.2a : East Asia's Machinery Trade (billions of US dollars)

	Total Machinery	Final products	Parts and Components	Parts to Total Machinery (%)
Exports				
1990	305.4	195.9	109.6	35.9
2005	1,476.2	715.6	760.6	51.5
Imports				
1990	138.3	70.6	67.7	49.0
2005	1,048.0	345.0	703.0	67.1

Source: UN Comtrade online

In addition, parts and components exports have grown faster than final product exports and total exports for most countries in East Asia. China has the highest double-digit growth for components and final product exports while Japan has the lowest growth rates of less than 5 percent. ASEAN-4 has a slightly higher growth rates than the average regional levels for all 3 commodity groups. Thailand has a higher growth in final product exports than components exports possibly because the country also has a high growth for a number of final product exports such as automobile, office machine, and computer.

Figure 2.2a: Average Annual Growth Rates of Machinery Exports, 1995-2005

It is interesting to note that parts and components trade has grown faster on the imports side than the exports side as clearly shown in Figure 2.2b and 2.2c. When looking at different countries in the region, China has a fastest growing share of parts and components in its machinery imports but the share of components exports remains

quite stable. Thailand has about half of machinery exports and almost two-thirds of machinery imports in the form of parts and components. ASEAN-4 had a lower share of components trade in 2005 than in 2000. This may be due to an increasing share of China in intra-regional trade. As a percentage of regional machinery exports and imports, more than 50 percent of exports and almost 70 percent of imports was parts and components.

Figure 2.2b: Share of Parts and Components in Total Machinery Exports

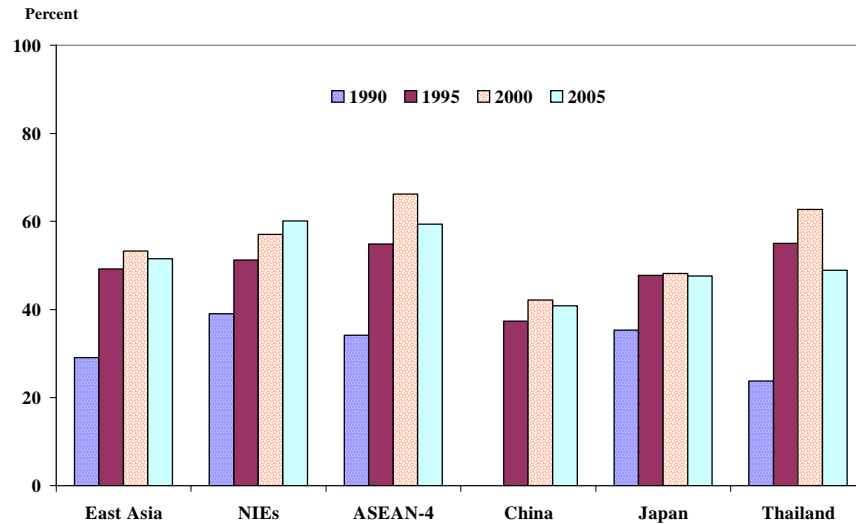
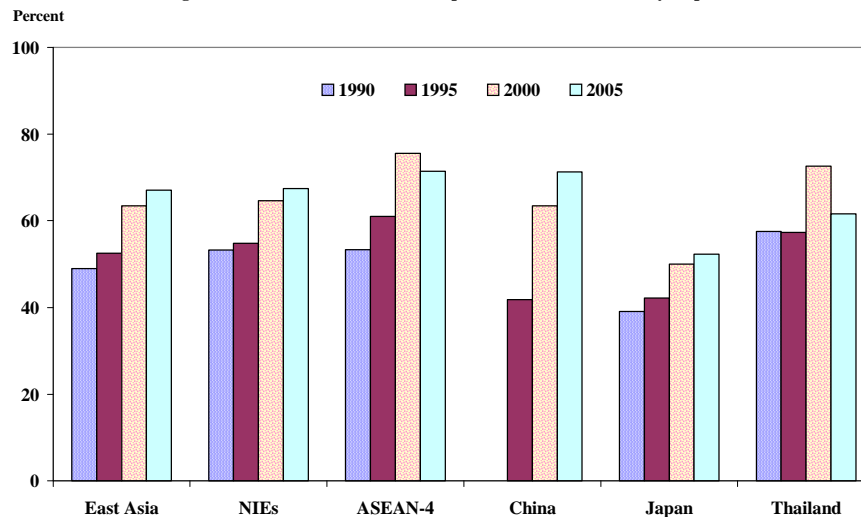


Figure 2.2c: Share of Parts and Components in Total Machinery Imports



To analyze further, we examine direction of parts and components trade within the region. Japan was the largest exporter in 1995 with 48 percent of total intra-regional exports while major importers included Singapore, Hong Kong SAR, Japan, Korea, and Malaysia. China made up only 4 percent for exports and 9 percent for imports in 1995. However, in 2005, Chinese exports rose up to 20 percent of total East Asian exports while the share of Japanese exports dropped to 26 percent. Thailand maintains its

export share of about 3 percent while import share shrinks to from 8 percent in 1996 to 4 percent in 2005. For ASEAN-4, its share of exports remained quite stable from 1995 to 2005. All countries in ASEAN-4 had a decline in their shares of regional imports over the same period while China became the largest importer in 2005.

Table 2.2b: Machinery Parts and Components Trade within Countries in East Asia (percent of exports/imports to East Asia)

Exporters	1995	2005	difference
East Asia	100.0	100.0	-
China	4.1	20.3	16.2
Hong Kong	10.2	15.1	4.8
Indonesia	0.5	1.0	0.5
Japan	48.2	26.2	-22.0
Malaysia	7.4	6.2	-1.2
Philippines	2.9	3.4	0.5
Singapore	13.1	11.1	-1.9
South Korea	10.3	13.3	3.1
Thailand	3.4	3.3	0.0
Importers	1995	2005	difference
East Asia	100.0	100.0	-
China	9.4	34.7	25.3
Hong Kong	15.7	16.3	0.6
Indonesia	3.6	1.1	-2.5
Japan	14.6	11.5	-3.1
Malaysia	12.4	7.5	-4.9
Philippines	4.9	3.7	-1.2
Singapore	20.0	12.6	-7.4
South Korea	11.3	8.3	-2.9
Thailand	8.1	4.3	-3.8

Source: UN Comtrade online

From our analyses in this section, a dominant feature of the changes in machinery trade in East Asia continues to be the evidence of China's rise in parts and components trade as a regional exporter and Japan's decline. There are two important messages to be drawn here. First, Japan has relied on other East Asian countries for component production and assembly bases to meet regional demand and to export to the rest of the world. Second, a substantial rise in the Chinese imports of parts and components from other emerging East Asian exporters is linked to an increase of China's growth of export to the rest of the world especially for machinery final products, reflecting its role as a regional assembly and export base.

3. Linkage between Parts and Components Trade and Production Network in East Asia

3.1 Intra-Trade in Electronics and Electrical Machinery Parts and Components

In section 2, we have provided some evidences that intra-machinery industry trade in East Asia has concentrated in the electrical machinery (HS85). In this section, we will discuss in more details about parts and components (P&C) trade in electrical machinery sector and the driving forces behind its rapid expansion. Electrical machinery sector usually includes electronics, electrical apparatus and appliances. According to the EU definition, electronics sector includes the following sub-sectors: computers and office equipment, telecommunication equipment, electronic components, and consumer electronics. Since electronics equipment is mostly used as inputs for many industries especially in electrical appliance and automobile industry, it is usually classified in the same group with electrical machinery.

In order to have more complete analysis, this paper will use a broad definition to cover both electronics components industry and electrical machinery industry. We adopt the HS85 which covers product ranges comparable to EU definition except for computers and office equipment which are classified under HS84. For the definition of electrical parts and components, we simply adopt the detailed 4-digit and 6-digit products under the HS85 from Ando and Kimura (2007) for our purpose. Details are in Appendix Table A6 and A7.

Table 3.1a : East Asia's Electrical Machinery Trade (billions of US dollars)

	year	1) Total Machinery	2) Machinery Parts and Components	Electrical Machinery			% Elec. Parts to total Machinery P&C = 5) / 2)	% Elec. Parts to Total Electrical Machinery = 5) / 3)
				3) Total	4) Final products	5) Parts and Components		
Exports								
East Asia	1990	305.4	109.6	102.9	49.3	53.6	48.9	52.1
	1995	673.7	331.6	294.0	100.5	193.5	58.4	65.8
	2005	1,476.2	760.6	662.4	231.7	430.7	56.6	65.0
China	1995	36.3	13.6	19.0	11.3	7.7	56.9	40.7
	2005	378.8	154.7	172.3	93.5	78.8	51.0	45.7
Japan	1990	218.6	77.1	63.8	32.3	31.5	40.8	49.4
	1995	334.7	159.9	108.5	32.6	75.9	47.5	69.9
	2005	419.1	199.6	122.3	34.8	87.5	43.8	71.6
Thailand	1990	14.5	3.4	2.7	1.1	1.6	47.3	60.7
	1995	20.3	11.1	9.7	3.4	6.3	56.3	64.7
	2005	51.7	25.3	20.7	7.1	13.6	53.7	65.6
Imports								
East Asia	1990	138.3	67.7	46.7	13.1	33.6	49.6	71.9
	2005	1,048.0	703.0	552.8	109.6	443.2	63.0	80.2
China	1995	56.9	23.8	19.4	6.8	12.7	53.3	65.2
	2005	342.1	243.9	174.8	20.9	153.9	63.1	88.0
Japan	1990	42.2	16.5	10.9	4.0	6.9	41.6	63.2
	1995	87.4	36.8	32.4	12.4	20.0	54.3	61.7
	2005	155.1	81.1	61.4	19.3	42.2	52.0	68.6
Thailand	1990	14.5	8.3	4.6	1.1	3.5	41.5	75.6
	1995	35.8	20.5	13.5	3.7	9.9	48.1	73.0
	2005	49.0	30.2	23.4	7.1	16.3	54.0	69.7

Source: UN Comtrade online

When we disaggregate “parts and components” from total electrical machinery, we find an interesting result. A large portion of parts and components has been observed in electrical machinery trade. Table 3.1a indicates that parts and components trade has been rapidly expanded over the last decade and has become significant driver of intra-machinery industry trade in the region. In 2005, almost two-thirds of electrical machinery exports were parts and components, rising from one-half in 1990. On the import side, parts and components represented around 80 percent of total electrical machinery imports. Thailand has almost 70 percent of parts and components in electrical machinery trade as the country has been one of major production bases for electrical appliances and electronic products. China has a sharp increase in parts and components imports (to almost 90 percent) suggesting that China has become a key importer of parts and components for its assembly production. A deficit in components trade in Thailand and China indicates that both countries are specialized in assembly operations of parts and components in vertical supply chains. Japan has supplied more and acquired more parts and components but the export value has been far greater than the import value. This trade surplus in components trade reflects the heavy involvement of Japanese companies in overseas assembly activities which are mainly located in East Asia (Athukorala and Yamashita, 2006)

Integrated circuits (IC) and microassemblies are the most important product in electrical machinery sector for East Asia with almost 30 percent of total exports and 44 percent of total imports. Other main commodities in this sector include semiconductors, television transmission and receive equipment, and electronic printed circuits. Structure of trade in electrical machinery for 2005 is provided in the Table A4.

In the last decade, exports of electrical machinery P&C have been highly concentrated within East Asia. During 1996-2005, East Asia to total electrical machinery exports has shifted its exports of electronics and electrical P&C towards markets within the region. In 1996, around 54 percent of total electrical parts and components exports were destined for regional market and the similar share went up to 66 percent in 2005. The share of regional exports of electrical P&C to EU15 decreased from 12 percent in 1996 to 8 percent in 2005 while share of NAFTA dropped sharply from 27 percent to only 10 percent.

Table 3.1b : Share of Electrical Machinery Parts and Components Exports by Region, 1996-2005 (percent)

	intra-regional			EU-15			NAFTA			Oceania		
	1996	2000	2005	1996	2000	2005	1996	2000	2005	1996	2000	2005
China	70.2	62.9	62.8	7.3	12.4	10.3	12.4	14.1	12.9	12.1	13.5	11.6
Hong Kong	64.0	67.7	81.1	9.5	9.2	5.5	14.8	13.5	5.9	1.0	0.5	0.4
Indonesia	63.1	67.0	76.3	10.1	9.3	4.7	17.7	15.8	7.5	1.0	1.1	1.4
Japan	52.1	51.0	60.3	11.3	13.2	9.2	36.0	22.8	11.8	0.5	0.4	0.3
Korea	44.7	51.4	64.4	13.2	12.0	5.6	31.6	23.6	10.8	0.3	0.3	0.3
Malaysia	53.8	56.4	58.1	12.2	14.0	11.7	22.6	20.4	4.9	0.4	0.3	0.3
Philippines	40.9	40.9	64.5	17.8	3.9	3.0	35.9	30.0	9.8	0.4	0.2	0.4
Singapore	58.6	55.3	67.2	11.9	12.5	9.4	17.7	17.9	11.0	17.7	17.1	10.8
Thailand	51.9	52.1	60.8	13.0	15.4	10.5	20.1	20.2	13.6	0.2	0.2	0.4
East Asia	54.1	54.8	66.1	11.7	11.9	8.3	27.0	20.4	10.1	3.8	4.1	4.1

Source: UN Comtrade online.

Using bilateral trade matrix in Table 3.1c below, we can examine direction of intra-trade in electrical machinery sector. For purpose of comparison, the bilateral trade of value greater than USD 5 Bn. is represented in the shaded area. In 1996, the total value of intra-trade in electrical parts and components in East Asia was almost US 200 billion, which was about 74 percent of total electrical machinery trade. In 2005, total intra-trade increased by almost three folds to 556 US billion. An extensive trade in electrical parts and components has been due to an increasing participation of China in vertical trade and regional production network in this sector. Although China increased its trade with ASEAN-4 as compared to 1996, its high-value trade was concentrated with Japan and NIEs.

Table 3.1c: Bilateral Trade Matrix of Electrical Machinery P&C within East Asia, 1996 and 2005

1996

	CN	ID	TH	MY	PH	SG	HK	KR	JP
CN	0.0	0.1	0.1	0.4	0.1	0.8	4.3	1.8	7.2
ID	0.1	0.0	0.1	0.2	0.0	0.6	0.1	0.2	0.5
TH	0.2	0.2	0.0	1.0	0.1	2.5	0.6	0.5	4.4
MY	0.4	0.4	1.1	0.0	0.8	10.7	1.8	2.3	8.8
PH	0.1	0.0	0.2	0.8	0.0	1.2	0.7	0.5	3.3
SG	1.0	0.0	3.1	15.9	1.5	0.0	3.6	3.2	10.4
HK	13.5	0.2	0.6	1.5	0.8	3.7	0.0	3.1	7.2
KR	1.4	0.4	0.5	2.6	0.6	3.1	2.6	0.0	9.3
JP	5.0	1.4	3.8	6.7	4.0	8.0	8.0	8.7	0.0

2005

	CN	ID	TH	MY	PH	SG	HK	KR	JP
CN	0.0	1.2	4.0	13.9	10.1	28.8	30.3	11.6	34.0
ID	0.4	0.0	0.3	0.3	0.1	1.8	0.2	0.2	1.0
TH	2.6	0.4	0.0	2.2	0.9	2.1	1.8	1.7	8.0
MY	6.6	0.9	2.3	0.0	3.0	9.2	6.6	4.7	8.1
PH	3.1	0.1	0.5	2.3	0.0	2.8	2.9	2.2	7.2
SG	13.6	6.3	3.9	23.3	4.4	0.0	10.6	9.1	10.7
HK	76.7	0.4	2.2	3.9	3.3	7.3	0.0	10.2	14.9
KR	22.6	0.7	1.3	2.6	2.5	6.1	6.8	0.0	12.8
JP	28.0	2.0	6.3	5.8	6.0	10.1	12.1	9.2	0.0

Source: UN Comtrade online

Note: In this table, trade refers to the sum of exports and imports

Figures in shaded area represent bilateral trade of value greater than 5 Bn.USD

East Asian trade in parts and components is considerably greater than often recognized. Even though electronics and electrical components are classified as high-tech products, their production involves many labor-intensive processes. Therefore, assembly operations are likely to migrate to relatively low wage Asian countries to take advantage of low cost production, while countries like Japan, Singapore, and Taiwan increased their specialization in the manufacture of components (Ng and Yeats, 2003).

In recent years, China has been a main driver of intra-trade in parts and components and a regional center for assembly production in electronic and electrical equipment. With its relatively low wage, China obtains a suitable position for combining expensive high-tech imported inputs from other East Asian countries and outside region with cheap domestic labor to assemble final goods that are exported mainly to developed markets in Europe and North America.

So far, we have documented some evidences showing the significance of intra-trade in parts and components within East Asia with an emphasis on electrical machinery sector. What are the driving forces behind this extensive trade? The intensified trading activities in East Asian region have been largely contributed to the ongoing international division of labor with production processes being relocated to low-cost assembly services and raw materials in developing East Asia. Specifically, the establishment of regional supply chains by multinational enterprises (MNEs) has driven the intra-regional trade within East Asia and has formed the regional production networks.

3.2 Literatures on International Production Fragmentation

The phenomenon of international production networks and components trade in East Asia can partially be explained by traditional theory based on North-South trade or differences in factor endowments. In the newly-developed trade theory, geographical location and transportation costs are incorporated when explaining trade across countries and the breaking up of an integrated production process into separate fragments which could be located in other areas within one country or other countries⁵.

The Fragmentation theory was first developed from Jones and Kierzkowski (1990). The framework has provided the understanding on international production sharing which could help to explain intra-trade patterns in East Asia. When the production process splits into many fragments (production blocks) located in different locations, the cost of production will be lowered since it is possible to select locations such that factor prices/ and or factor productivities are for each fragment more suited to factor proportions in that fragment. The basic idea of fragmentation is feasible when the service link costs are low enough so that the fragmentation becomes cost-saving. Service link activities include transportation, communication and coordination services that are required to establish a functioning network among production blocks located in different geographical locations. The terms including production fragmentation, production sharing or production/ distribution network are often used interchangeably to refer to the sliding up of production process according to this theory.

Ando and Kimura (2005) proposed the concept of fragmentation and agglomeration⁶ in order to capture the international production/ distribution networks in East Asia. They argued that East Asian production/ distribution networks incorporate

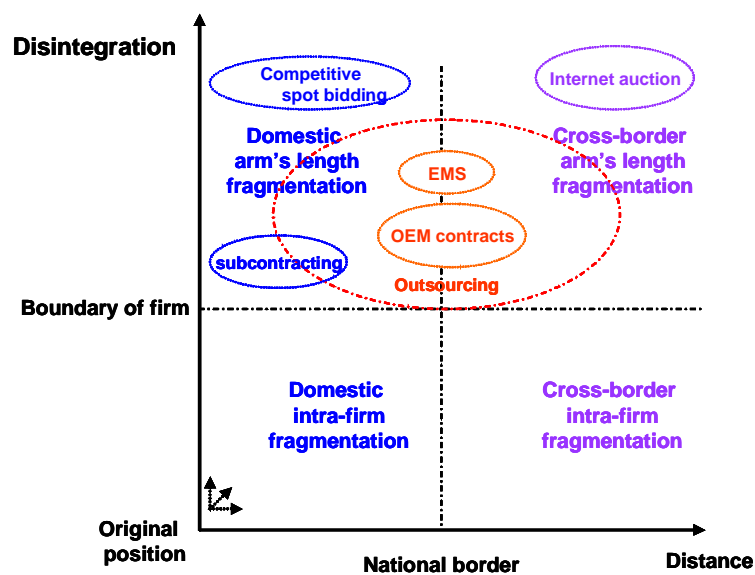
⁵ See Krugman (1991), Ng and Yeats (2001), Jones and Kierzkowski (1990, 2001a, 2004).

⁶ See Ando and Kimura (2005, 2007) and Kimura (2006) for more detailed explanation of the two-dimensional fragmentation framework.

sophisticated combination of intra-firm and inter-firm (arm's-length) transactions which are more sophisticated than the original idea form of fragmentation in the US-Mexico nexus and the Western Europe-Central and Eastern Europe corridor. The mechanics of two-dimensional fragmentation are presented in Figure 3.2a

The vertical axis denotes disintegration or uncontrollability of corporate activities as we go along the axis while the horizontal axis represents geographic difference. Two dotted lines in the middle are the boundary of firm and national border, representing tradeoffs in fragmentation decision. The boundary of firm distinguishes intra-firm transactions from inter-firm transaction while the national border distinguishes between cross-border fragmentation and domestic fragmentation. A firm's decision for fragmentation depends on cost savings in production blocks and the service link costs. Cost savings in production come from differences in location advantages along the vertical disintegration axis. Service link costs are measured along the horizontal axis as they are associated with geographic distance and transaction costs arising from firm's weaker controllability.

Figure 3.2a: Two-dimensional Fragmentation Framework



Source: Ando and Kimura (2007)

Recent literatures have explained the rapid expansion of East Asian intra-trade is based largely upon the transactions between multinational enterprises (MNEs) and their affiliates in the region. Important motive underlying MNEs to establish production bases in different locations is to take advantage of low cost where host countries are specialized in the production of different stages in an assembly line. In the next section, we will investigate some evidences on production fragmentation and the presence of MNEs business activities in order to shed some lights on the production network in East Asia.

3.3 Evidences of Fragmentation and the Role of Japanese MNEs in East Asian Production Networks

In many developing countries, assembly operations in electronics industry located especially semiconductor devices, hard disk drives have been the most active sector. Other industries with extensive labor-intensive assembly operations include electrical appliances, automobile parts, electrical machinery, optical products, musical equipment, watches, and cameras (Athukorala, 2006). In East Asia, production and distribution network has not been limited only to machinery sector. Well-established network has also been observed in labor-intensive industries such as textiles and garment as well as services sector. However, machinery sector has been the major player and the most sophisticated network in East Asia and in other regions. In particular, international production distribution/networks in East Asia has been the most developed in the world in terms of 1) their significance to each economy in the region⁷, 2) their extensiveness of the networks covering a large number of countries, and 3) their sophistication of intra-firm and inter-firm (arm-length) transaction (Ando and Kimura, 2005).

How production fragmentation can be observed? Although production sharing arrangements across Asia have promoted regional economic and trade integration since 1990s, such integration is structurally linked to the international business networks of MNEs⁸. Therefore, the extensive intra-trade is one of the consequences of the ongoing trade-FDI nexus within the region. In many East Asian countries; for example, electronics and electrical machinery sector have received substantial FDI especially from Japan. Japanese affiliates in East Asia acquire parts and components from developed countries especially from their Japanese parent companies or from other developing economies for their assembly production and sell their finished products to the markets particularly outside East Asia.

From trade data of Japan, we can observe the trend of business activities between Japanese parent companies and their overseas affiliates located in different regions. The characteristic of Japanese production fragmentation has changed over time and the Japan's network in East Asia has been expanded while its network in other regions has shown no significant growth in the recent decade. It is clearly seen from Table 3.3a that about one-thirds of Japan's exports are destined for overseas affiliates. From 1995 to 2005, exports to Asian affiliates have grown faster than those to other regions with almost 40 percent of total exports to all overseas affiliates. In contrast, exports to affiliates in Europe and North America have been quite stable in recent years. The latter half of the table shows the trend in reverse imports from overseas affiliates. Almost one-fifths of Japan's imports are reversed supplies from all affiliates with Asian affiliates contributing more than 80 percent. There was a small growth or

⁷ Electrical machinery constitutes a significant proportion of exports and imports for many countries in East Asia. For example, in case of Thailand, electrical machinery has been ranked the first on top ten export products with almost 20 percent share of total exports.

⁸ See Asian Development Outlook (2007).

contraction in imports from affiliates in Europe, North America, and other regions during 2004-2005.

Table 3.3a : Trend in Japan Trade with Overseas Affiliates

Exports to Overseas Affiliates				
	1995	2000	2004	2005FY
Value of Exports (Bn. Yen)	7,016	14,216	20,525	21,979
of which: Asia	2,800	5,223	7,835	8,736
North America	2,623	5,445	6,654	6,949
Europe	1,303	2,765	5,026	4,997
Others	289	784	1,010	1,297
% of total exports	17.1	28.5	34.9	33.7
Reverse Imports from Overseas Affiliates				
	1995	2000	2004	2005FY
Value of Imports (Bn. Yen)	3,425	6,113	8,460	9,307
of which: Asia	2,271	4,924	6,630	7,780
North America	517	681	1,042	767
Europe	118	287	351	384
Others	519	222	437	376
% of total imports	11.6	16.0	18.5	16.7

Source: The 36th Survey on Overseas Business Activities by METI

Note: Reverse imports = Sales to Japan by overseas affiliates in manufacturing industries

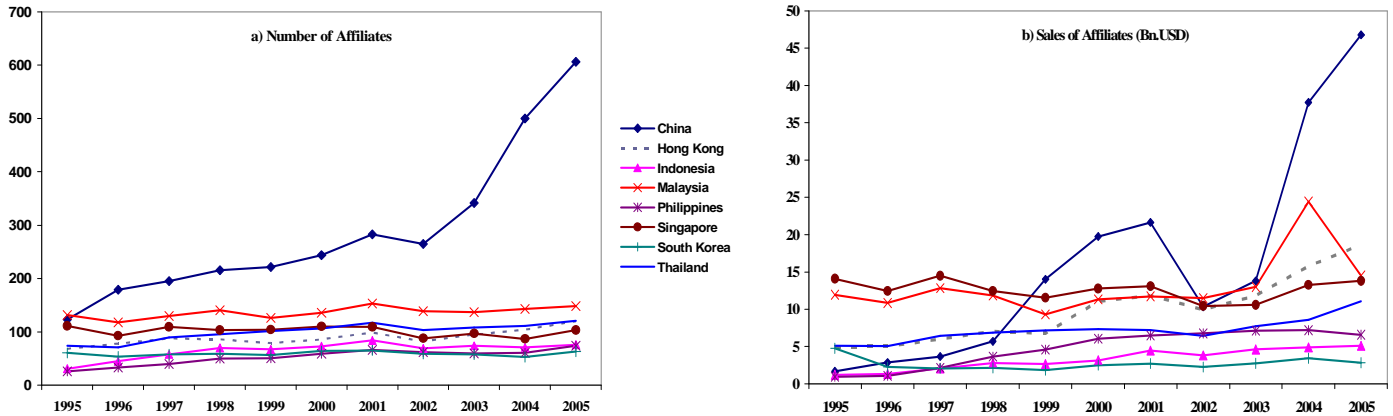
Due to unavailability of data on MNEs activities from Hong Kong SAR, Korea, and Singapore, we will mainly focus on Japanese MNEs and their operations in East Asia. So, our analysis in this section is presumably downward bias. From the Survey on Overseas Business Operations conducted by JBIC, more than half of the Japanese manufacturing affiliates are located in East Asia. Most countries are concentrated more on production than sales activities especially for ASEAN-4 and China. On the other hand, Japanese manufacturing firms have more or less the same proportion of production bases and sales bases in Europe and North America. This indicates that Japanese firms are attracted to East Asia for production purpose due to relatively low cost of labor. On the other hand, affiliates in Europe and North America are set up due to both demand (market attractiveness) and supply (cost reduction) purposes. The recent trend for Japanese manufacturing companies has been the relocation of production functions to China from countries with rising labor costs, such as Taiwan, Singapore, and Malaysia. There have also been cases of production being relocated from EU, North America and Mexico to Asia.

Table 3.3b : Number of Overseas Affiliates by Japanese Manufacturing Companies

	East Asia				Other Asian Countries	North America	EU-15	Others	Total
	Total	NIEs	ASEAN-4	China					
Production Base	3,331	593	1,146	1,592	215	719	444	406	5,115
Sales Base	2,019	927	493	599	108	614	831	445	4,017
R&D Base	103	17	23	63	4	76	52	14	249
Others	324	101	93	130	17	195	113	122	771
Total	5,777	1,638	1,755	2,384	344	1,604	1,440	987	10,152

Source: Survey Report on Overseas Business Operations by Japanese Manufacturing Companies (as of November 2006)

Figure 3.3: Number of Japanese Affiliates and Sales made by Japanese Affiliates in Electrical Machinery Sector



The presence of Japanese MNEs activities in East Asia has been more substantial than other regions for electrical machinery sector. Within East Asia, the number of affiliates in China has increased much faster than those in other countries in the region especially during the last few years as shown in Figure 3.3 a). On the right-hand side pane, sales figures have also increased in line with the number of affiliates. Sales made by affiliates in China still grew faster than other countries and it soared in 2005.

Japanese MNEs currently send more than 80 percent of their exports from Asian Affiliates to other Asian countries and obtain 95 percent of their imports from Asian producers⁹. Japanese affiliates in electronic machinery sector exhibits the high dependence on trade, especially on intra-regional trade, in their procurements and sales, reflecting the presence of regional production network¹⁰. To capture the essence of regional production sharing, back and forth transactions of Japanese MNEs and their affiliates are also investigated. Table 3.3c shows that Japanese affiliates in electrical machinery sector located in East Asia generally have high proportion of sales/purchases to their total sales compared to the ratio for total machinery sector. The by-destination sales/purchases ratios in local transactions for Japan and for East Asia are much higher than others, suggesting that activities of Japanese affiliates are highly concentrated within the region.

Besides, intra-firm transactions are quite significant with Japan. In contrast, inter-firm or arm's length transactions are common in local transactions. Further evidence suggests that affiliates of Japanese firms in East Asia have relatively large intra-firm transactions in electrical machinery sector for both sales and purchases. These affiliates actively trade with other East Asian countries and also with their Japanese parent firms. See Appendix Table A5 for details.

⁹ See Gill and Kharas (2007).

¹⁰ See Urata (2004).

Table 3.3c : Sales and Purchases by Japanese Affiliates in East Asia

	by-destination sales ratio (%)						Intra-firm transaction sales ratio (%)					
	Japan			Local Third countries			Japan			Local Third countries		
				East Asia	North America	Europe				East Asia	North America	Europe
a) Sales												
1995 Machinery total	20.8	56.6	22.6	12.8	4.0	1.9	90.6	19.9	55.4	60.2	64.8	71.5
Electrical Machinery	28.7	38.0	33.2	19.6	5.6	2.2	88.9	9.0	52.6	59.5	56.7	58.4
2001 Machinery total	29.1	40.1	30.9	19.9	5.8	2.9	79.3	13.7	52.6	51.6	62.4	47.6
Electrical Machinery	34.4	31.2	34.4	22.0	7.4	2.8	77.6	15.6	54.3	55.8	55.7	52.4
	by-origin purchases ratio (%)						Intra-firm transaction sales ratio (%)					
	Japan			Local Third countries			Japan			Local Third countries		
				East Asia	North America	Europe				East Asia	North America	Europe
b) Purchases												
1995 Machinery total	29.3	43.3	27.5	18.6	4.7	2.7	76.2	9.3	53.6	54.3	59.1	46.3
Electrical Machinery	38.9	33.8	27.3	24.8	1.3	0.2	86.0	14.1	46.5	45.9	33.1	48.2
2001 Machinery total	38.0	40.3	21.7	20.2	0.7	0.3	69.9	10.1	46.4	45.4	64.7	41.3
Electrical Machinery	35.3	35.2	29.4	28.0	0.5	0.3	74.4	8.6	44.7	44.4	33.3	39.0

Source: Ando and Kimura (2007)

Note: Third countries are countries other than Japan and local.

The high concentration of transactions with Japan and within the region can reflect two important characteristics of intra-regional trade. First, sales/purchases transactions are most likely to be associated with back and forth transactions of parts and components trade particularly among Japanese parent companies and their affiliates in East Asia. These transactions clearly represent a close association between intra-regional trade and the production network and the linkage is strong in electrical machinery sector. Second, changes in the patterns of intra-regional trade have been closely related with evolution of production network. Over the last decade, intra-trade in electrical machinery sector has been intensified as the extensiveness of production fragmentation has expanded especially from the increasing participation of China and greater sophistication of back and forth transactions within the region.

4. Gravity Model of Trade Integration

The intensified intra-regional trade in electrical machinery sector has been proved to be significant for East Asian trade in previous sections. The rapid expansion of parts and components trade has led to the changing patterns of intra-trade and has represented the existence of production networks in the region. To gain deeper understanding of trade integration within East Asia, this section will formally test the intra-trade in machinery sector in East Asia. Disaggregation of trade data in machinery sector and electrical machinery sub-sector are employed to study the determinants of intra-trade in different commodity groups within these sectors.

4.1 Model Specification

The gravity model of bilateral trade flows has been used as the workhorse for empirical analysis in international trade (Athukorala, 2003). For the purpose of our study, we use a basic gravity model by adding a number of explanatory variables. We are interested to analyze parts and components trade vis-à-vis final product trade in total machinery and electrical machinery sub-sector. The augmented gravity equations for four commodity groups are performed in this study: 1) total machinery (HS 84-92), 2) total electrical machinery (HS85), 3) electrical machinery final product, and 4) electrical machinery parts and components. In order to analyze the change in trade patterns, we use the pooled data from 1996 to 2005 since the export data of electrical machinery for Philippines are available from 1996. The bilateral export flows are obtained from the UN Comtrade online. Our exporting countries include nine countries in East Asia; namely, Japan, China, Hong Kong, South Korea, Singapore, Malaysia, Philippines, Thailand, and Indonesia. Due to lack of bilateral trade data from the UN Comtrade, Taiwan is not included in our study. See appendix for data description and sources.

The GDP of exporting country and the GDP importing country are used as a proxy for the size of economy. According to international trade theory, the larger the economy size of both trading partners, the more trade can be expected to occur between two countries. The distance variable is used as a proxy for the service link cost particularly the transport (shipping cost) and other associated costs. Geographical distance enable firms to diversify location advantages including wages, economic infrastructure, policy environment, etc (Ando and Kimura, 2007). The coefficient of distance variable for final product trade is expected to be different from that for parts and components trade. Parts and components trade reflects the value-added chain or assembly production in vertical intra-industry trade so it is expected to be more sensitive to the national border effect. Many studies on trade integration include per capita GDP as a proxy for income to capture the positive effect over and above the effect of GDP. Two countries with different level of GDP per capita are likely to trade more than those with similar one. We will also test whether per capita GDP is significant in our equations.

The dummy variable EASINT is a proxy for regional trade bias. Trading partners located in East Asian region are expected to trade more with each other especially for parts and components. We will also test whether the relative labor cost¹¹ is a determinant of bilateral trade flow in our dataset. Bilateral export flow is used as our dependent variable.

¹¹ Following Jones (2000), and Fukao and Athukorala (2007), the relative labor cost is calculated from $RER_{i,j} = NER * (P^W_i / P^D_j)$ where NER is the nominal bilateral exchange rate index, P^W_i is the price level of country i measured by the producer price index, and P^D_j is the domestic price of country j measured by GDP deflator.

Our gravity equation is specified below:

$$\ln X_{ij,t} = \alpha + \beta_1 \text{DIST}_{i,j} + \beta_2 \ln \text{GDP}_i + \beta_3 \ln \text{GDP}_j + \beta_4 \text{LAN}_{i,j} + \beta_5 \text{EAINT}_{i,j} + \gamma T + \varepsilon_{i,j}$$

where subscripts i and j refer to the exporting country and importing country with the postulated sign of regression coefficient for the explanatory variables in brackets.

X	bilateral trade flow between country i and country j based on the reporter country's export at 2000 prices
DIST	distance in kilometers between i and j (-)
GDP	Real gross domestic product (+)
EAINT	A dummy variable which is unity if i and j are located in East Asia (+)
LAN	A dummy variable which is unity if i and j have a common language (+)

4.2 Results of Gravity Estimation

Regression coefficients of main variables including real GDP and distance are statistically significant with expected signs in all equations. From our results, the magnitude of distance coefficient declines gradually from equation 1 to equation 4. However, there is no significant difference in geographical distance between trade in parts and components and trade in final products as we expected. The market size of importing country seems to be more important than that of exporting country in our model, particularly for parts and components trade (equation 4). This can be explained by the importance of location advantage in assembly production and/or transport cost involving in back and forth trade transactions.

Table 4.2a: Estimation Results of Gravity Equations

Explanatory variables	(1) Total Machinery		(2) Electrical Machinery		(3) Electrical Machinery Final Product		(4) Electrical Machinery Parts and Components	
	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.
distance	-1.286 ***	0.293	-1.087 ***	0.271	-0.953 ***	0.233	-0.939 ***	0.328
GDP, exporter	0.778 ***	0.081	0.701 ***	0.100	0.780 ***	0.087	0.615 ***	0.084
GDP, importer	0.909 ***	0.115	0.827 ***	0.138	0.776 ***	0.119	0.995 ***	0.124
Common Language Dummy	0.829 ***	0.300	0.658 *	0.361	0.748 *	0.386	1.119 ***	0.341
Intra-East Asia Dummy	0.229	0.431	1.391 ***	0.395	-0.239	0.385	2.577 ***	0.561
Constant	-14.538 ***	4.009	-12.373 **	4.924	-13.972 ***	4.396	-17.619 ***	4.948
ρ	0.923		0.941		0.904		0.926	
Number of observations	2,410		2,404		2400		2,396	
adjusted R2	0.959		0.962		0.922		0.958	
F	3788.573		4085.346		1903.821		3631.338	

Note: 1) The standard errors (SEs) of the regression coefficients are adjusted for heteroskedasticity and serial correlation.

2) Statistical significance is denoted as *** 1 percent, ** 5 percent and * 10 percent.

Per capita GDP was initially included in our basic gravity equations. Since there was a strong presence of serial correlation problem, we correct for the problem by including an AR term in our model. Per capita GDP is no longer significant after adjusting for serial correlation so we drop this variable. In addition, relative labor cost variable which represents the competitiveness of exporting country in trading the given commodity with respect to importing country is not significant in all equations. This should not be interpreted that labor cost is not a determinant of bilateral trade but rather a combination of labor cost along with other factors are important for creating trade between two countries. However, our results remain unchanged with the inclusion or exclusion of this variable.

Common language variable is very significantly higher for parts and components trade than for any other commodity group. This indicates that parts and components trade tend to be higher among trading partners located in the same region (which are likely to share similar languages) than those located in different regions. The intra East Asia dummy variable is positive and statistically significant for parts and components trade while it is neither positive nor significant for final product trade. This result is consistent with the situation in East Asia. Large portion of final product is destined for market outside the region so being insiders may not be very important.

To measure the change of trade patterns, we conduct gravity estimations for two periods of 1996-2000 and 2001-2005. The results are shown in Appendix Table A9. There are significant differences among four commodity groups across the two time periods. Distance and GDP of exporter country become more important in 2001-2005 period than the previous 1996-2000 period. In contrast, GDP of importer country becomes less significant in recent years compared to 1996-2000. Interestingly, final good trade becomes less significant in the recent period and the intra-East Asian dummy is not significant for either of the two periods. This indicates that final good trade is not a dominant feature of intra-regional trade in electrical machinery sector. On the other hand, parts and components trade is quite robust for 2001-2005 period. Intra-East Asian dummy is also very significant for both periods, reflecting the linkage between intra-trade and production bases located in different countries in East Asia especially during the recent years.

5. Policy Issues

In this paper, the intensification of intra-trade has been increased in the last decade especially in the machinery sector and electrical machinery sub-sector. This trend is likely to continue in the coming decades. The extensive trade integration is also found to have a close link with the production fragmentation led by transnational companies. The formation of production network has been developed through export-oriented and FDI-promotion policies in many developing East Asia from late 1980s or early 1990s (Kimura, 2007). Given the above facts, how should East Asia gain the most benefit from the well-established production distribution network? And more

importantly, how should individual country position itself both in regional and global level?

One crucial question can provide an initial step to find policy implications. Has intra-East Asian trade growth become less dependent on demand outside the region? It is estimated that 78.8 percent of East and Southeast Asia's exports is destined for final demand outside the region and some evidences indicate that about 60 percent of Asian exports are headed for G3. Therefore, the rise in intra-Asian economic interdependence through investment and trade has been driven by globalization process (Asian Development Outlook, 2007). The region has become even more dependent on the global economy. Since the globalizing activities of multinational corporations and their affiliates play a crucial role in intra-regional trade, the future of intra-trade will inevitably be evolved in line with the changes in patterns of international production sharing and the MNEs business operations and strategies.

The higher dependence of final demand outside the region and more exposure to globalization calls for East Asia to maintain its competitive position in the world market. Given this supply side structure, policy issue concerning countries in the region is how to further strengthen regional production networks. Although Japan's role of regional exporter has been partially replaced by China's, Japan remains the center of regional production network. Since research and development activities are mostly conducted within the parent companies, Japan plays a leading part in regional product development and innovation to meet final demand in Europe and the US. This role is particularly important in the case of the electronics and electrical machinery sector where product technology and designs are constantly changing.

Alongside with product development led by MNEs, supply chains or production blocks in developing East Asia need to keep pace with production technology and innovation in order to supply high-quality parts and components in the regional assembly lines. In recent years, many developing countries have been increasingly competing for FDI. Low labor cost is necessary but not sufficient factor for attracting FDI. It is crucial for policymakers in developing East Asia to provide sound investment environment for business operations of MNEs. Some evidences show that regional investment climate is more important in promoting production networks than differences in nationalities.

For MNEs, a number of priority factors in overseas investment decision include infrastructure development, clear legal system, protection of intellectual property, stable local security and social conditions, and competition in the local market, etc. Complementarities among outward-oriented development, investment promotion, and international trade policies are also necessary to maintain investors' confidence and prospect in host countries. From the recent survey report by JBIC, law enforcement, intense competition, and infrastructure development have been cited as main issues concerning Japanese manufacturing companies in China while unstable security social conditions and under-developed infrastructure are major concerns for Indonesia. Besides, governments in developing East Asia can further enhance location advantages by decreasing service link costs such as logistics improvement and facilitation of

document procedures. In recent years, many countries in East Asia have actively pursued bilateral and multinational trade agreements such as Free Trade Area (FTA), and Economic Partnership Agreement (EPA). Due to the difficulty of the rules of origin; however, the implementation of these agreements has been slow and the benefit of FTA or EPA cannot be fully obtained. More simplified rules of origin are necessary to make possible for the region to attain the gains from these agreements in the longer term. Although many countries in East Asia have engaged in a number of trade agreements within the region, policy arrangements directly aiming for enhancement of regional production network have not been created. Policymakers in East Asia should also use existing trade arrangements as a channel to foster deeper economic cooperation including intra-trade facilitation and development of regional production network.

Implications for Thailand

What kind of policies should Thailand pursue to attain most benefit from intensified intra-trade and regional production chains? As one of the main suppliers in regional supply chain, Thailand needs to set policy priorities regarding trade, foreign investment, and domestic industrial development.

It is important for Thailand to identify its current position and development in regional network. From JBIC FY 2006 survey report, Thailand is still on the top five promising countries for Japanese manufacturing MNEs. Three most important reasons for promising prospect are inexpensive labor force, market growth potential, and supply base for manufacturers. However, main issues concerning business operations in Thailand include the intense competition in the local market, difficulty in securing local managers, and increase in labor costs.

With the increasing role of China as a source of low-cost raw materials and labors, Thailand needs to enhance the development of production technology and skilled-labor in order to move up higher on the value chain. Government should also encourage more active participation of local enterprises in the regional production / distribution network. To sustain long-term development of Thailand, technology transfer and knowledge spillover particularly from parent companies to affiliates in Thailand should also be actively promoted.

6. Conclusion

This paper has shown how the pattern of intra- trade in machinery sector has evolved in the last decade both in terms of composition and redirection of trade among countries within East Asia. Japan and China are the two centers of intra-trade dynamism in the region. The phenomenon in East Asia is fundamentally linked to the ongoing activities and expansion of regional production networks. The rise of intra-regional parts and components trade is found to be highly associated with trading activities between parent companies and their affiliates in the production network in the region. Given the strong dependence on final demand outside the region, trade

integration in East Asia is still tied to globalization and exposed to global business cycle.

The increasing role of China in the regional production network has brought significant changes to both in intra-trade and extra-trade patterns in East Asia. Specifically, China has become a major trading partner for many other East Asian economies. It has played a center role in triangular trade by connecting the source of supply in Japan and final demand in Europe and the US.

Going forward, the outsourcing production and business strategies led by MNEs have underpinned the region's export growth success and these will continue to shape trade patterns in the region.

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Appendix

Table A1: Trade in Machinery in East Asia

Export	Total Machinery				Finished products				Parts and Components			
	1990	1995	2000	2005	1990	1995	2000	2005	1990	1995	2000	2005
East Asia												
Total Value (Bn. USD)	305.4	673.7	880.1	1,476.2	195.9	342.0	411.1	715.6	109.6	331.6	469.0	760.6
of which:												
China	n.a.	36.3	90.7	378.8	n.a.	22.8	52.5	224.1	n.a.	13.6	38.2	154.7
Hong Kong	n.a.	67.4	92.2	169.7	n.a.	33.4	37.5	55.2	n.a.	34.0	54.8	114.5
Indonesia	0.5	4.2	11.4	14.2	0.4	2.6	5.6	6.8	0.0	1.6	5.7	7.4
Japan	218.6	334.7	359.7	419.1	141.4	174.8	186.3	219.4	77.1	159.9	173.3	199.6
Malaysia	15.6	42.1	63.4	80.7	8.7	17.6	22.3	33.3	6.9	24.5	41.1	47.4
Philippines	n.a.	18.7	29.5	31.6	n.a.	9.1	6.3	5.8	0.0	9.5	23.2	25.7
Singapore	29.8	81.4	98.9	144.0	17.9	38.1	36.0	59.4	11.9	43.3	63.0	84.6
South Korea	26.6	68.6	102.9	186.4	16.5	34.5	52.9	85.0	10.1	34.1	50.0	101.4
Thailand	14.5	20.3	31.4	51.7	11.0	9.1	11.7	26.4	3.4	11.1	19.7	25.3
Import												
Import	Total Machinery				Finished products				Parts and Components			
	1990	1995	2000	2005	1990	1995	2000	2005	1990	1995	2000	2005
East Asia												
Total Value (Bn. USD)	138.3	479.7	589.3	1,048.0	70.6	227.8	215.2	345.0	67.7	251.9	374.1	703.0
of which:												
China	n.a.	56.9	99.7	342.1	n.a.	33.1	36.4	98.2	n.a.	23.8	63.3	243.9
Hong Kong	n.a.	81.7	102.1	170.5	n.a.	42.3	40.6	56.2	n.a.	39.4	61.4	114.3
Indonesia	9.7	17.0	9.7	15.8	5.9	8.0	4.4	8.0	3.8	9.0	5.3	7.8
Japan	42.2	87.4	122.0	155.1	25.7	50.5	60.9	73.9	16.5	36.8	61.1	81.1
Malaysia	15.6	48.4	53.7	69.2	6.5	17.2	11.0	16.5	9.1	31.2	42.7	52.7
Philippines*	n.a.	18.7	18.3	29.5	n.a.	6.3	3.6	3.5	n.a.	12.4	14.7	26.0
Singapore	29.8	78.0	88.0	120.1	13.2	27.7	26.1	31.7	16.6	50.3	61.9	88.4
South Korea	26.6	55.9	66.5	96.8	13.1	27.5	24.0	38.1	13.4	28.4	42.5	58.6
Thailand	14.5	35.8	29.4	49.0	6.1	15.3	8.1	18.8	8.3	20.5	21.3	30.2

Source: Author's calculation based on the UN Comtrade

Note: For Philippines, value of exports and imports in 1995 are from the 1996 levels.

Table A3 : Share of Machinery Trade by Commodity in 1996 and 2005

1) Exports (percent of total machinery exports)

HS code	Commodity	year	East Asia	ASEAN-4	CN	HK	ID	JP	MY	PH	SG	KR	TH
84	Nuclear reactors, boilers, machinery, etc	1996	32.3	35.6	27.0	25.4	21.9	32.7	25.5	68.1	46.1	19.0	41.7
		2005	31.1	33.4	39.5	26.8	32.1	28.5	33.8	26.3	32.0	20.7	37.4
85	Electrical, electronic equipment	1996	41.8	55.1	49.9	54.9	60.5	30.9	67.5	25.3	46.9	49.7	44.8
		2005	44.9	54.1	45.5	61.8	51.5	29.2	59.7	63.9	59.8	43.2	40.0
86	stock, equipment	1996	0.4	0.3	2.8	0.0	1.2	0.1	0.2	0.0	0.0	1.3	0.3
		2005	0.5	0.1	1.7	0.0	0.5	0.3	0.1	0.0	0.0	0.1	0.0
87	Vehicles other than railway, tramway	1996	14.0	2.1	4.2	2.8	5.2	24.0	1.0	2.8	1.5	16.6	3.3
		2005	13.3	6.7	4.4	1.0	9.1	29.9	1.0	5.1	1.9	20.1	15.8
88	Aircraft, spacecraft, and parts thereof	1996	0.6	2.0	0.4	0.2	0.6	0.3	2.2	0.2	0.6	0.3	3.1
		2005	0.4	1.1	0.2	0.1	0.8	0.3	0.5	1.1	1.0	0.2	2.0
89	Ships, boats and other floating structures	1996	2.9	0.8	2.9	0.0	3.6	3.1	0.8	0.0	0.8	10.1	0.6
		2005	2.4	0.7	1.2	0.0	1.4	2.8	0.7	0.4	0.7	9.2	0.5
90	apparatus	1996	6.0	2.8	7.4	7.6	3.8	8.1	2.2	2.3	2.9	2.1	4.1
		2005	6.6	3.5	6.7	6.6	2.3	8.6	4.0	2.8	4.2	6.4	3.4
91	Clocks and watches and parts thereof	1996	1.8	1.1	4.9	8.8	1.3	0.6	0.6	1.3	1.1	0.4	2.0
		2005	0.7	0.4	0.5	3.5	0.0	0.2	0.2	0.5	0.4	0.1	0.8
92	Musical instruments, parts and accessories	1996	0.3	0.2	0.6	0.2	2.0	0.3	0.1	0.0	0.1	0.5	0.1
		2005	0.2	0.2	0.2	0.1	2.3	0.2	0.1	0.0	0.0	0.1	0.0

2) Imports (percent of total machinery imports)

HS code	Commodity	year	East Asia	ASEAN-4	CN	HK	ID	JP	MY	PH	SG	KR	TH
84	Nuclear reactors, boilers, machinery, etc	1996	35.6	36.1	51.0	24.5	55.5	33.3	29.0	30.3	33.4	41.8	38.9
		2005	29.0	30.3	28.1	25.2	51.0	33.7	26.4	20.9	29.3	28.9	34.8
85	Electrical, electronic equipment	1996	43.2	44.6	32.1	54.5	22.9	37.0	55.5	50.5	50.7	35.5	37.6
		2005	52.7	54.8	51.1	64.1	21.0	39.6	61.1	69.8	57.4	50.4	47.8
86	Railway, tramway locomotives, rolling stock, equipment	1996	0.2	0.2	0.1	0.2	0.3	0.2	0.2	0.1	0.0	0.5	0.4
		2005	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0
87	Vehicles other than railway, tramway	1996	7.6	10.5	3.7	6.2	15.0	13.4	6.4	10.1	3.2	3.7	14.1
		2005	4.6	7.1	3.6	1.6	19.3	8.9	4.6	4.4	3.3	4.3	8.2
88	Aircraft, spacecraft, and parts thereof	1996	3.3	3.1	4.5	2.2	1.3	2.6	2.9	4.9	3.6	4.5	3.2
		2005	2.0	2.0	1.9	0.6	3.0	3.1	1.6	1.6	3.1	1.4	2.4
89	Ships, boats and other floating structures	1996	1.4	1.3	0.7	0.1	1.3	0.3	1.9	0.5	3.1	3.2	1.0
		2005	0.4	1.1	0.1	0.1	2.1	0.1	1.2	0.0	0.5	1.2	1.2
90	Optical, photo, technical, medical, etc apparatus	1996	6.6	3.5	6.0	6.0	3.4	11.0	3.5	3.0	4.5	10.3	3.8
		2005	10.1	4.1	14.6	5.7	3.1	12.7	4.5	2.7	5.5	13.3	4.8
91	Clocks and watches and parts thereof	1996	2.0	0.6	1.8	6.1	0.0	1.9	0.6	0.5	1.3	0.5	0.8
		2005	0.9	0.5	0.3	2.7	0.1	1.4	0.4	0.4	0.7	0.2	0.7
92	Musical instruments, parts and accessories	1996	0.2	0.1	0.1	0.2	0.2	0.4	0.0	0.0	0.1	0.1	0.1
		2005	0.1	0.1	0.0	0.1	0.2	0.3	0.1	0.0	0.0	0.1	0.1

Source: UN Comtrade online

Note: Shaded area represents the share in 2005 which was higher than the corresponding 1996 level.

Table A4: Structure of Electronics and Electrical Machinery Parts and Components Trade in East Asia, 2005

HS code	Product	East Asia										EU-15	US	Oceania
		Total	China	Hong Kong	Indonesia	Japan	Malaysia	Philippines	Singapore	Korea	Thailand			
1) Exports														
85	Electrical machinery	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8507	Electric accumulators	1.6	2.5	1.5	3.4	2.4	0.3	0.2	1.4	0.3	0.6	1.1	0.9	0.6
8518	Audio-electronic equipment, except recording devices	1.5	2.6	2.4	3.6	0.3	1.3	0.3	1.0	0.5	0.6	1.0	1.5	1.1
8522	Parts, accessories of audio, video recording equipment	2.1	2.6	5.5	1.7	0.8	0.8	0.1	1.1	0.8	2.8	0.1	0.1	0.1
8529	Parts for radio, tv transmission, receive equipment	8.8	10.5	12.5	4.9	8.8	3.0	2.3	13.3	3.3	3.7	4.2	4.2	4.5
8534	Electronic printed circuits	2.8	3.1	3.7	8.3	2.6	3.2	1.0	1.7	1.3	6.1	0.9	1.6	1.2
8535	Electrical apparatus for voltage over 1 kV	0.2	0.0	0.1	0.2	0.4	0.2	0.0	0.1	0.4	0.2	0.8	0.4	3.0
8536	Electrical switches, connectors, etc, for < 1kV	2.9	2.2	4.5	3.7	4.7	1.1	2.7	1.0	2.6	2.7	5.8	5.1	4.2
8541	Diodes, transistors, semi-conductors, etc	5.3	2.5	4.1	2.6	7.7	7.0	33.1	1.5	5.7	4.0	2.1	4.1	6.1
8542	Electronic integrated circuits and microassemblies	26.6	8.5	24.7	5.0	23.8	40.7	41.3	30.3	56.4	26.6	12.7	32.4	4.2
8544	Insulated wire and cable, optical fibre cable	2.0	2.8	1.7	6.9	1.6	1.1	4.0	1.8	0.5	3.2	4.2	4.1	7.0
8547	Insulating fittings for electrical equipment	0.2	0.1	0.0	0.1	0.5	0.0	0.0	0.1	0.1	0.1	0.4	0.1	0.1
8548	Electrical parts of machinery and apparatus, nes	0.3	0.1	0.0	0.6	0.6	0.0	0.0	0.3	0.4	2.4	0.4	0.5	0.2
	others	45.8	62.6	39.3	59.1	46.1	41.4	15.0	46.5	27.6	47.0	66.2	98.4	67.7
2) Import														
85	Electrical machinery	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
8507	Electric accumulators	1.4	2.2	1.5	0.7	1.0	0.7	0.3	1.2	0.5	0.3	1.2	1.0	1.3
8518	Audio-electronic equipment, except recording devices	1.1	0.8	1.7	1.5	1.9	0.8	0.3	1.4	0.8	0.7	1.4	1.7	2.1
8522	Parts, accessories of audio, video recording equipment	1.7	1.8	3.5	0.3	1.3	1.0	0.5	0.5	0.8	1.2	0.3	0.1	0.1
8529	Parts for radio, tv transmission, receive equipment	7.1	9.5	8.9	3.0	9.3	3.0	1.9	4.8	4.0	2.0	3.9	3.1	2.2
8534	Electronic printed circuits	3.2	3.8	3.5	0.6	2.1	4.5	3.6	2.6	1.9	3.6	1.0	1.1	0.5
8535	Electrical apparatus for voltage over 1 kV	0.2	0.2	0.1	1.7	0.1	0.4	0.3	0.1	0.3	0.2	0.3	0.2	0.8
8536	Electrical switches, connectors, etc, for < 1kV	3.2	3.3	3.7	5.9	3.6	2.7	1.5	2.8	2.7	4.3	4.8	3.4	3.8
8541	Diodes, transistors, semi-conductors, etc	5.5	6.4	5.4	0.5	4.1	5.3	2.3	5.0	6.6	3.5	2.7	1.9	1.0
8542	Electronic integrated circuits and microassemblies	44.1	47.0	32.7	2.9	30.3	59.0	78.5	43.3	53.7	34.1	12.2	10.4	5.3
8544	Insulated wire and cable, optical fibre cable	2.0	1.6	1.6	5.2	5.6	1.0	0.9	2.1	1.1	3.0	4.9	5.2	4.9
8547	Insulating fittings for electrical equipment	0.1	0.1	0.0	0.3	0.1	0.1	0.6	0.1	0.1	0.3	0.2	0.1	0.0
8548	Electrical parts of machinery and apparatus, nes	0.2	0.0	0.0	0.0	0.1	0.1	0.1	0.8	0.3	0.5	0.4	0.1	0.0
	others	30.2	23.2	37.5	77.3	40.6	21.5	9.1	35.3	27.1	46.3	66.7	71.8	78.2

Source: UN Comtrade Online.

Table A5: Intra-firm and arm's length of Electrical Machinery transactions by Japanese Affiliates in East Asia

	East Asia		NIEs-4		ASEAN-4		China	
	1995	2001	1995	2001	1995	2001	1995	2001
a) Sales								
of electrical machinery (bn.JPY)	5,107	8,539	2,793	3,542	1,984	3,595	311	1,298
% of total sales	20.8	23.7	11.4	9.8	8.1	10.0	1.3	3.6
share (%)								
1) Japan	28.7	34.4	22.6	30.3	36.2	40.0	29.7	32.2
- intra-firm	25.6	26.7	19.9	18.0	32.1	35.7	28.3	26.5
- arm's length	3.2	7.7	2.7	12.3	4.1	4.4	1.4	5.8
2) Local	38.0	31.2	45.4	41.4	29.3	18.5	34.1	37.2
- intra-firm	3.4	4.9	3.2	4.1	3.8	5.6	2.5	5.7
- arm's length	34.6	26.3	42.2	37.4	25.5	12.9	31.6	31.6
3) Other East Asia	19.6	22.0	17.4	16.4	20.3	26.8	30.8	22.0
- intra-firm	11.6	12.3	9.2	7.5	11.7	14.2	27.9	17.0
- arm's length	7.9	9.7	8.1	8.9	8.6	12.6	2.9	5.0
4) East Asia = 1)+2)+3)	86.3	87.6	85.3	88.1	85.9	85.3	94.6	91.4
- intra-firm	40.6	43.9	32.3	29.6	47.6	55.4	58.6	49.1
- arm's length	45.7	43.8	53.0	58.6	38.2	29.9	35.9	42.3
b) Purchases								
of electrical machinery (bn.JPY)	2,834	6,249	1,455	2,653	1,157	2,602	209	919
% of total sales	19.5	23.3	10.0	9.9	8.0	9.7	1.4	3.4
share (%)								
1) Japan	38.9	35.3	37.8	40.8	37.1	28.3	53.3	38.3
- intra-firm	33.5	26.3	33.6	33.1	30.7	19.4	45.1	24.9
- arm's length	5.4	9.0	4.2	7.7	6.4	8.9	8.2	13.4
2) Local	33.8	35.2	38.4	31.3	31.2	38.7	18.7	37.3
- intra-firm	4.8	3.0	7.5	3.6	1.8	2.1	1.8	4.1
- arm's length	29.0	32.2	30.8	27.7	29.4	36.6	16.9	33.2
3) Other East Asia	24.8	28.0	20.4	26.3	30.1	31.2	27.0	23.8
- intra-firm	11.4	12.4	12.0	12.8	7.9	10.5	22.4	16.1
- arm's length	13.4	15.6	8.4	13.5	22.2	20.7	4.6	7.8
4) East Asia = 1)+2)+3)	97.5	98.5	96.6	98.4	98.4	98.2	99.0	99.5
- intra-firm	49.6	41.7	53.1	49.5	40.4	32.0	69.3	45.0
- arm's length	47.9	56.8	43.5	48.9	58.0	66.2	29.7	54.4

Source: Ando and Kimura (2007)

Note: Original data are available in the Survey of Overseas Business Activities of Japanese Companies compiled by the Ministry of Economy, Trade, and Industry (METI).

Table A6 : Definition of Electrical Machinery Parts and Components

HS Code	Coverage
8503	Parts for electric motors and generators
850490	Parts of electrical transformers and inductors
8505	Electro and permanent magnets, equipment using magnet
850690	Parts of primary cells and primary batteries
8507	Electric accumulators
850890	Parts, hand tools with self-contained electric motor
850990	Parts of domestic appliances with electric motor
851090	Parts of shavers/hair clippers, electric
8511	Ignition/starter equipment, internal combustion engine
8512	Electric lighting, signal equipment, car electric accessories
851390	Parts for portable battery & magneto electric lamps
851490	Parts of industrial/etc electric furnaces/ovens etc
851590	Parts of electric solder, weld or braze equipment
851690	Parts of electro-thermic apparatus, domestic, etc
851790	Parts of line telephone/telegraph equipment, etc
8518	Audio-electronic equipment, except recording devices
8522	Parts, accessories of audio, video recording equipment
8529	Parts for radio, tv transmission, receive equipment
853090	Electric signal, safety & traffic controller parts
8531	Electric sound or visual signal equipment etc
8532	Electrical capacitors, fixed, variable or adjustable
8533	Electrical resistors and rheostats except for heating
8534	Electronic printed circuits
8535	Electrical apparatus for voltage over 1 kV
8536	Electrical switches, connectors, etc, for < 1kV
8537	Electrical power, etc, control and distribution board
8538	Parts for electrical switches, protectors, connectors
8539	Electric filament, discharge lamps
8540	Thermionic and cold cathode valves and tubes
8541	Diodes, transistors, semi-conductors, etc
8542	Electronic integrated circuits and microassemblies
854390	Parts of electrical machines and apparatus etc
8544	Insulated wire and cable, optical fibre cable
8545	Carbon electrodes, brushes and electrical items etc
8546	electrical insulators of any material
8547	Insulating fittings for electrical equipment
8548	Electrical parts of machinery and apparatus, etc

Source: Ando and Kimura (2007)

Table A7: Definition of machinery parts and components

840140,840290,840390,840490,840590,8406,8407,8408,8409,8410,8411,8412,8413,8414,841520,841590,8416,8417,841891,841899,841990,842123,842129,842131,842191,842199,842290,842390,842490,8431,843290,843390,843490,843590,843680,843691,843699,843790,843890,843991,843999,844090,844190,844240,844250,844390,8448,845090,845190,845240,845290,845390,845490,845590,8466,846791,846792,846799,846890,8473,847490,847590,847690,847790,847890,847990,8480,8481,8482,8483,8484,8485,8503,850490,8505,850690,8507,850890,850990,851090,8511,8512,851390,851490,851590,851690,851790,8518,8522,8529,853090,8531,8532,8533,8534,8535,8536,8537,8538,8539,8540,8541,8542,85439,8544,8545,8546,8547,8548,8607,8706,8707,8708,870990,8714,871690,8803,8805,9001,9002,9003,900590,900691,900699,900791,900792,900890,900990,901090,901190,901290,9013,9014,901590,901790,902490,902590,902690,902790,902890,902990,903090,903190,903290,9033,9110,9111,9112,9113,9114,9209

Source: Ando and Kimura (2005,2007)

Table A8 : Definition of Region and Sample Countries in the Gravity Estimation

East Asia : Japan, China, Hong Kong, South Korea, Singapore, Malaysia, Thailand, Philippines, Indonesia

ASEAN-4 : Malaysia, Thailand, Philippines, Indonesia

NIEs : South Korea, Hong Kong, Singapore

Sample Countries in the Gravity Estimation

EU-15 : United Kingdom, Belgium, Finland, Germany, France, Sweden, Austria, Luxemburg, Portugal, Denmark, Italy, Netherlands, Spain, Ireland, Greece

NAFTA: United States, Canada, Mexico

Oceania : Australia, New Zealand

Table A9: Estimation Results of Gravity Equations

Explanatory variables	(1) Total Machinery				(2) Electrical Machinery				(3) Electrical Machinery Final Goods				(4) Electrical Machinery Parts and Components			
	1996-2000		2001-2005		1996-2000		2001-2005		1996-2000		2001-2005		1996-2000		2001-2005	
	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.	coefficient	S.E.
distance	-1.049 ***	0.360	-1.851 **	0.779	-0.795 ***	0.287	-2.265 **	1.129	-0.735 ***	0.247	-1.388 **	0.647	-0.770	0.485	-1.165 ***	0.420
GDP, exporter	0.548 ***	0.095	1.475 ***	0.341	0.457 ***	0.076	1.911 ***	0.446	0.565 ***	0.080	1.378 ***	0.370	0.511 ***	0.100	0.803 ***	0.174
GDP, importer	1.000 ***	0.111	0.645 **	0.294	0.998 ***	0.118	0.270	0.451	0.845 ***	0.118	0.468	0.304	1.177 ***	0.160	0.727 ***	0.212
Language Dummy	1.058 ***	0.378	0.436	0.711	1.032 ***	0.348	-0.467	1.570	1.246 ***	0.429	-0.189	0.966	0.716 *	0.408	1.769 ***	0.651
Intra-EA Dummy	0.578	0.544	-0.587	1.069	1.781 ***	0.460	0.569	1.337	-0.229	0.415	-0.105	0.982	2.948 ***	0.913	2.211 ***	0.526
Constant	-12.776 ***	4.339	-25.030 **	12.713	-13.061 ***	4.026	-30.225	20.453	-12.246 ***	4.445	-21.103	13.481	-21.177 ***	6.838	-16.195 ***	7.717
Observations	1,156		1,254		1,153		1,251		1,151		1,249		1,151		1,245	
adjusted R2	0.951		0.967		0.962		0.964		0.917		0.928		0.951		0.964	
F	2,260		3,665		2,882		3,322		1,268		1,621		2,253		3,286	
ρ	0.900		0.961		0.915		0.980		0.865		0.952		0.916		0.942	

Note: 1) The standard errors (SEs) of the regression coefficients have been adjusted for heteroskedasticity and serial correlation.

2) Statistical significance is denoted as *** 1 percent, ** 5 percent and * 10 percent.

Table A10: Data Description and Source

Variable	Description	Source
X	bilateral export flow in US\$ at 2000 prices using the US wholesale price index	UN Comtrade online
GDP	GDP at 2000 prices	World Development Indicators
GDPPC	GDP per capita at 2000 prices	World Development Indicators
DIST	distance calculated following the great circle formula, which uses latitudes and longitudes of the most important city (in terms of population) or of its official capital.	The CEPII's database http://www.cepii.fr/anglaisgraph/bdd/distances.htm
LAN	A binary dummy variable which takes a value of one if two countries share a common official language	The CEPII's database http://www.cepii.fr/anglaisgraph/bdd/distances.htm
EASIA	A binary dummy variable which takes a value of one if two countries are in East Asia	