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International Production Networks: Comparison between China and ASEAN

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Abstract: Although East Asia experiences splendid economic growth with the development of international production networks, remaining development gaps across countries and regions are still large. This paper compares regions within China and countries in ASEAN in terms of the degree of participation in international production networks and discusses similarities and differences between China and ASEAN in the conceptual framework of extended fragmentation theory. Examining intra-East-Asian exports of machinery products by regions/countries, we find that China and ASEAN share a number of common features. However, China presents a hint of convergence in regional trade patterns while ASEAN seems to stagnate in its trickle-down effects on latecomers.

***Keywords*:** China export; ASEAN export; export variety; fragmentation; agglomeration

***JEL Classification*:** F14; F23

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1. Introduction

Since the 1990s, East Asia including Northeast and Southeast Asia has presented a novel development model in which the mechanics of international production networks have aggressively utilized. By taking advantage of globalizing forces of corporate activities, a number of East Asian countries have successfully captured economic dynamism in the region and have accelerated industrialization. International production networks, however, have not yet covered the whole East Asia. While Japan, Korea, Taiwan, Hong Kong, the coastal area of China, and a part of ASEAN (Association for Southeast Asian Nations) including Singapore, Malaysia, and Thailand have become key players, inland China as well as the rest of ASEAN has not yet been fully connected with international production networks. Narrowing development gaps among countries and regions has remained as a major issue in the process of deepening economic integration in East Asia.

China and ASEAN have presented inspiring resemblance and contrast in the degree of participation in international production networks. Although both China and ASEAN came from behind after Japan and Asian Newly Industrialized Economies (NIEs) for industrialization, they became essential participants in international production networks in East Asia. On one hand, China and ASEAN have roughly the same size of geographical extension and still retain substantial disparities in income levels and development stages inside. On the other hand, they widely differ in population size and recent economic growth rates particularly after the Asian currency crisis. China is a unified nation state while ASEAN is a gathering of independent countries with different languages, diversified historical and cultural backgrounds, and largely uncoordinated national policies. These similarities and differences seem to generate resembling yet distinguished patterns of participation in international production networks.

The fragmentation theory with a flavor of new economic geography is proved to be a powerful conceptual tool for analyzing the mechanics of production networks (Kimura and Ando, 2005). It convincingly argues that international production networks have developed in effectively utilizing gaps in income levels and development stages as a

source of different location advantages while reducing service link costs to connect remotely located production blocks. It also explains the mechanism of forming industrial agglomerations with active arm's-length (inter-firm) vertical division of labor. The essence of new economic geography presents the mechanism of possible trickle-down effects from cores to peripheries when trade costs are reduced. The comparison between China and ASEAN surely provide an opportunity for checking the functioning of the conceptual framework.

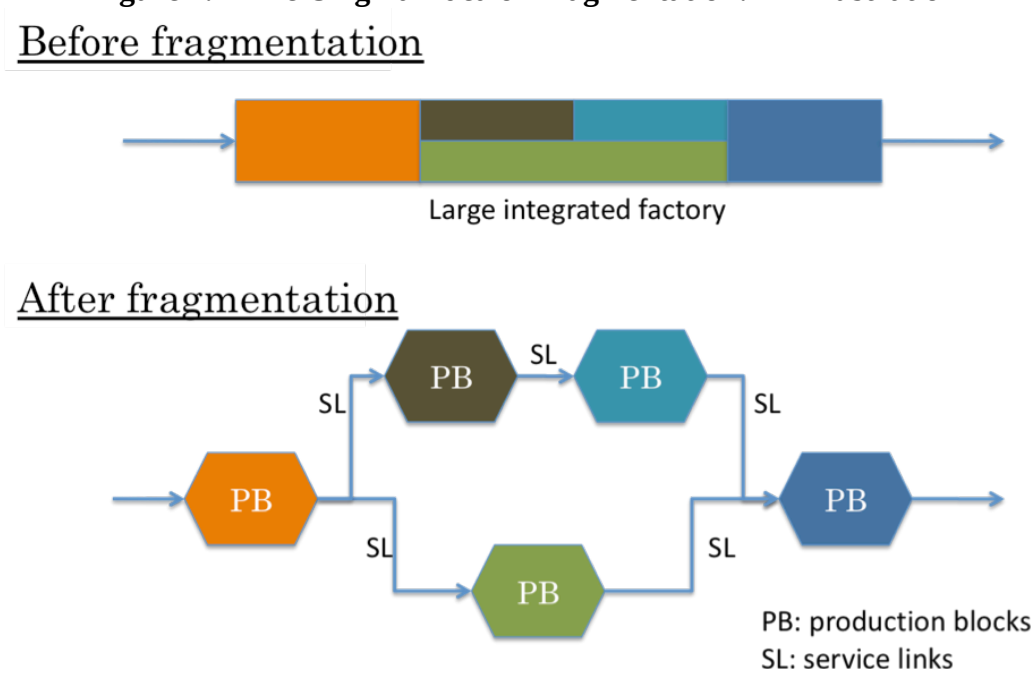
Although the formation of international production networks has been observed in various industries such as chemicals, textiles and garments, and software, the central actors in East Asia have no doubt been machinery industries (Ando and Kimura, 2005; Kimura, Hayakawa, and Ji, 2008). International production networks in machinery industries are important not only quantitatively but also qualitatively. Machines typically consist of a large number of parts and components that require a wide spectrum of technologies depending on multiple producers in various locations. The production-process-wise international division of labor, rather than the traditional industry-wise division of labor, generates back-and-forth intra-industry transactions of machinery parts and components among countries at different development stages. Hence, international trade data, particularly shares of intra-East-Asian machinery exports in total intra-regional exports, indicate the degree of participation in international production networks for each country or region fairly well.

This paper examines international trade data of China by customs and those of ASEAN by countries and analyzes the similarities and differences in the penetration of international production networks of machinery industries into regions in China and countries in ASEAN. The paper plan is as follows: the next section sketches the essence of fragmentation theory extended with a flavor of new economic geography as a conceptual framework for the mechanics of international production networks. Section 3 discusses similarities and differences of China and ASEAN and overviews the degree of participation in East Asian production networks. Section 4 further investigates the pattern of networking among regions in China and countries in ASEAN by calculating various indicators for trade patterns. The last section summarizes and discusses our findings.

2. The Extended Fragmentation Theory

The fragmentation theory initiated by Jones and Kierzkowski (1990) and its extension are an essential conceptual tool for understanding the mechanics of fragmentation. Figure 1 illustrates the basics of fragmentation. Suppose that this is an electronics company and the whole production from downstream to upstream are originally located in one country. If we closely look at the factory, however, it includes various production processes in terms of technologies, required factor inputs, and connection with other production processes. Hence, if we can separate production processes into production blocks and relocate them to remote places with different location advantages, the total production costs may be reduced. Such fragmentation of production processes becomes viable if (i) production costs per se are substantially saved in fragmented production blocks and (ii) additional cost of connecting remotely located production blocks, i.e., service link costs, is not prohibitively high. Service link costs include transport costs, telecommunication costs, various coordination costs, and others.

Figure 1. The Original Idea of Fragmentation: An Illustration



Condition (i) means that the larger differences in location advantages between two countries/regions, the more likely fragmentation is viable. Wage levels of unskilled labor are no doubt one of the important determinants of location choices but do not fully represent multi-dimensional aspects of location advantages. Firms have a degree of freedom in how to cut off production blocks so that they can take advantage of various niches in local investment climate. Condition (ii) is also crucial when latecomers try to attract economic activities. Geographical positioning is one of the important factors for service link costs. Service link costs are partially controllable by government policies though; trade facilitation and the development of logistic infrastructure and services are typical policies to reduce service link costs. Service link often has strong economies of scale in both static and dynamic sense, which would adversely affect latecomers.

To accommodate the sophistication of international production networks in East Asia, Kimura and Ando (2005) extend the concept of fragmentation into two dimensions: fragmentation in terms of geographical distance and the disintegration of corporate activities. The latter is particularly important in the context of East Asia, which explains the proliferation of arm's length, i.e., inter-firm, transactions including various classes of outsourcing such as subcontracting, OEM (original equipment manufacturing or original equipment manufacturer)/ODM (original design manufacturing or original design manufacturer) contracts, EMS (electronics manufacturing service) firms, foundries, and internet auction. The development of arm's length transactions in production networks, in addition to intra-firm transactions, is compatible with recent innovative business models in which the concentration of resources to core competences and the choice of business architecture, i.e., modular versus total integration, are crucial.

The introduction of disintegration-type fragmentation is also important to explain the simultaneous advancement of firm-level fragmentation and industry- or macro-level agglomeration, which we have indeed experienced in East Asia much earlier than in other developing regions in the world. Arm's length transactions, particularly in tight just-in-time (JIT) system, are highly sensitive to geographical distance, which generates geographical concentration of vertical arm's length transactions in order to save transaction costs. This is one of the economic forces that accelerate the formation of

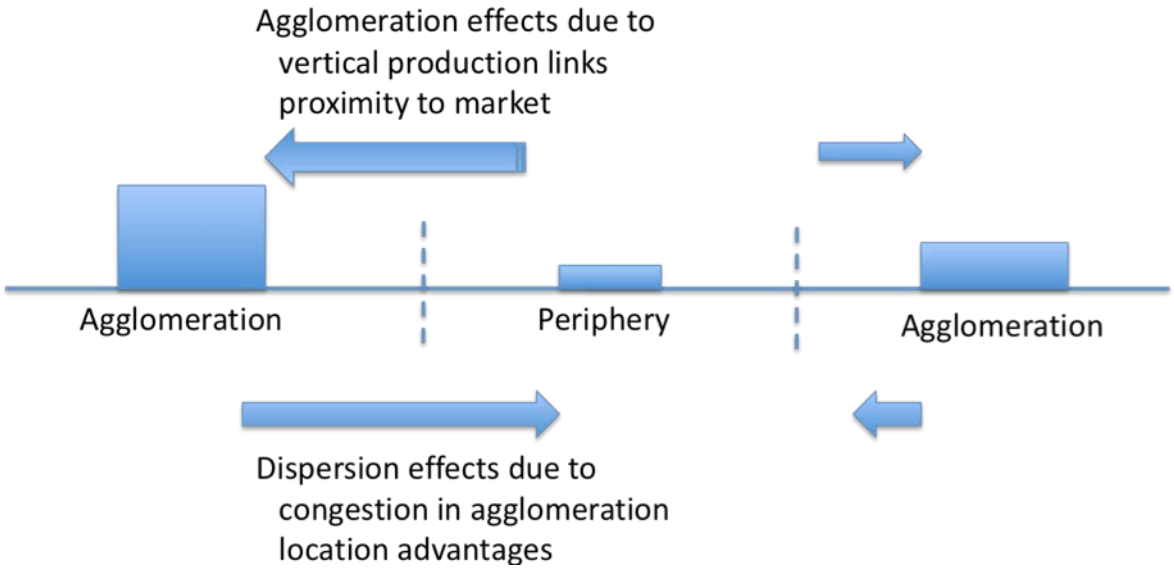
industrial agglomeration. In cases of machinery industries, most of the high-frequency just-in-time transactions in vertical division of labor are actually conducted with a gate-to-gate lead time of 2.5 hours or less, which roughly corresponds to a geographical boundary of 100km diameter; transactions with such a short lead time are called the "first-layer" transactions by Kimura (2008). Once industrial agglomeration starts working, it becomes an important element of location advantages itself, particularly in terms of counterbalancing wage hikes as economic development proceeds. Industrial agglomeration also provides ample opportunities for local firms and entrepreneurs to penetrate into production networks developed by multinationals.

Negative agglomeration effects or congestion effects generate dispersion forces with which some of the economic activities in industrial agglomeration, typically labor-intensive activities, start looking for new production sites in peripheries. From the viewpoint of lagging-behind countries/regions, such forces provide opportunities to invite production blocks if proper improvement of location advantages and the reduction in service link costs are prepared. Investment in lagging-behind countries/regions may be new investment by multinationals or takes a form of satellite plants from neighboring agglomerations. This is an important channel for latecomers to initiate industrialization by taking advantage of globalizing forces.

The dynamics of agglomeration and dispersion is nonlinear and complex. New economic geography describes the mechanism of concentration and dispersion forces between cores and peripheries (see Figure 2).[1] When the mobility of goods and productive factors enhances due for example to logistic infrastructure development and trade facilitation, we may have equilibria in which a larger amount of economic activities is attracted to the core or equilibria in which more economic activities move from the core to the periphery, depending on delicate parameter conditions. As a development strategy, we may want to upgrade industrial agglomeration further, which is the essential step toward fully developed economic society. At the same time, if we care for narrowing development gaps, peripheries may need to improve investment climate in order to take advantage of dispersion forces.

[1] See, for example, Baldwin, Forslid, Martin, Ottaviano, and Robert-Nicoud (2003).

Figure 2. Agglomeration and Dispersion Forces: An Illustration



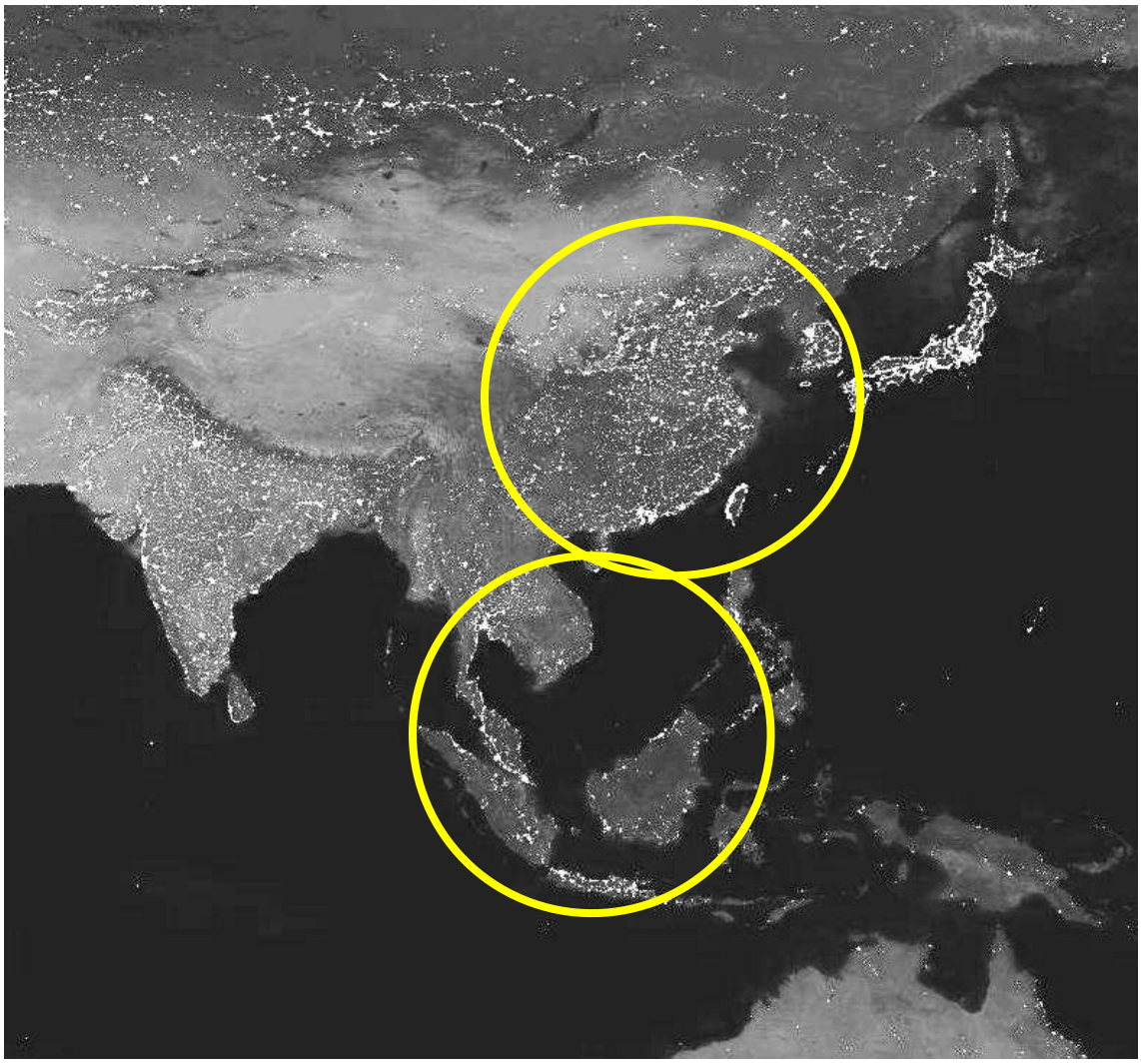
3. China and ASEAN in East Asian Production Networks

With the mechanics of fragmentation and agglomeration in our mind, let us start with an overview of China and ASEAN in the context of international production networks. We compare China and ASEAN from three aspects, i.e., the size, income levels, and prospects of economic integration, in order to assess the potential of utilizing the mechanics of international production networks and then evaluate the penetration of international production networks by international trade data.

The first checkpoint is the size. China and ASEAN have roughly the same size in their geographical extension (Figure 3). If we draw a circle of 1,500km diameter, core parts of China and ASEAN are almost included. This is actually the size of the whole Europe covering Madrid and Moscow or the size of the United States from Massachusetts to Colorado. This is much larger than the geographical size of one industrial agglomeration that is typically within a diameter of 100km. Each region or country in China and ASEAN is individually connected with Japan, Asian NIEs, and other industrial agglomerations outside. Connections between China and ASEAN are

also growing recently.[2] In addition, we can expect the formation of satellite connections among regions within China and among countries in ASEAN.

Figure 3. Geographical Coverage of China and ASEAN



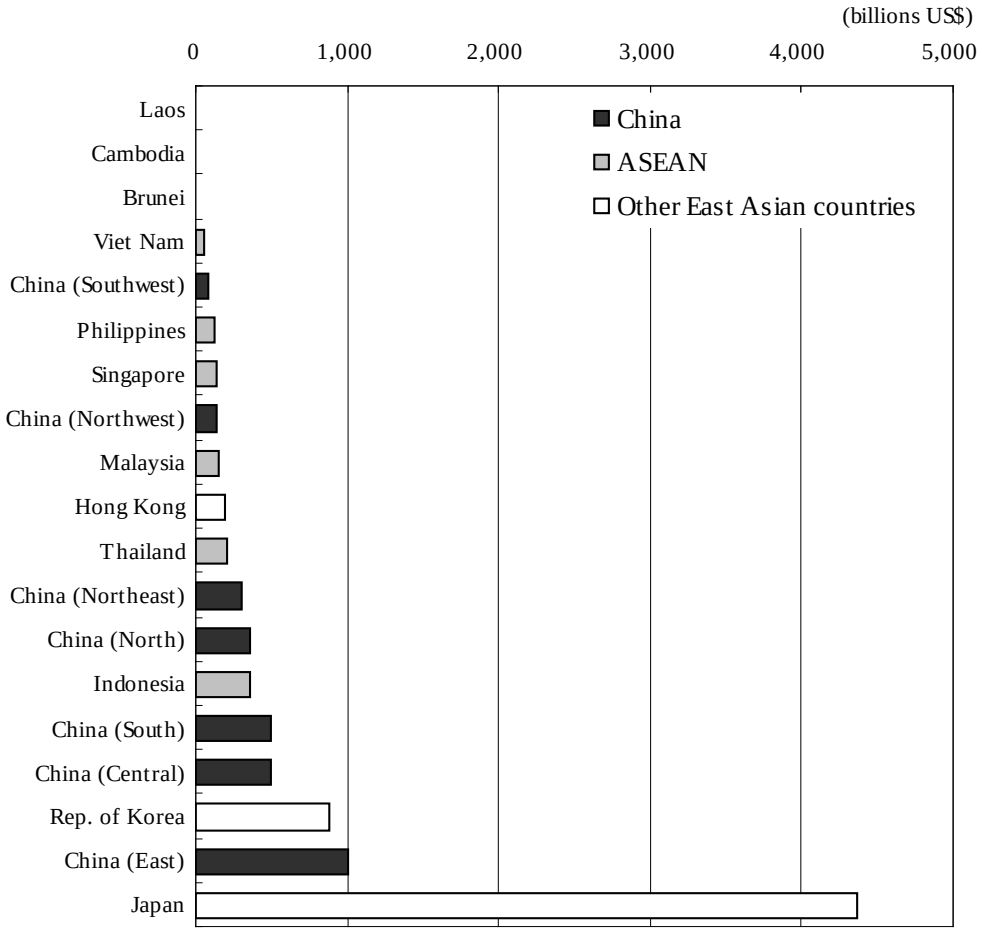
Note: The diameter of each circle is about 1,500km.
Source: The image obtained from the wage page of NASA Images (http://www.nasaimages.org/) is modified by authors.

By dividing China into seven regions as shown in the Appendix, Figures 4 and 5 present the size of gross regional/domestic products (GRP, GDP) and population of each region within China and each country in East Asia. Each region within China is

[2] Although the rise of China has triggered fears of increased competition, China also has grown appetite for imports and has offered business opportunities particularly for Asian neighbor countries including ASEAN (Eichengreen et al., 2007; Greenaway et al., 2008).

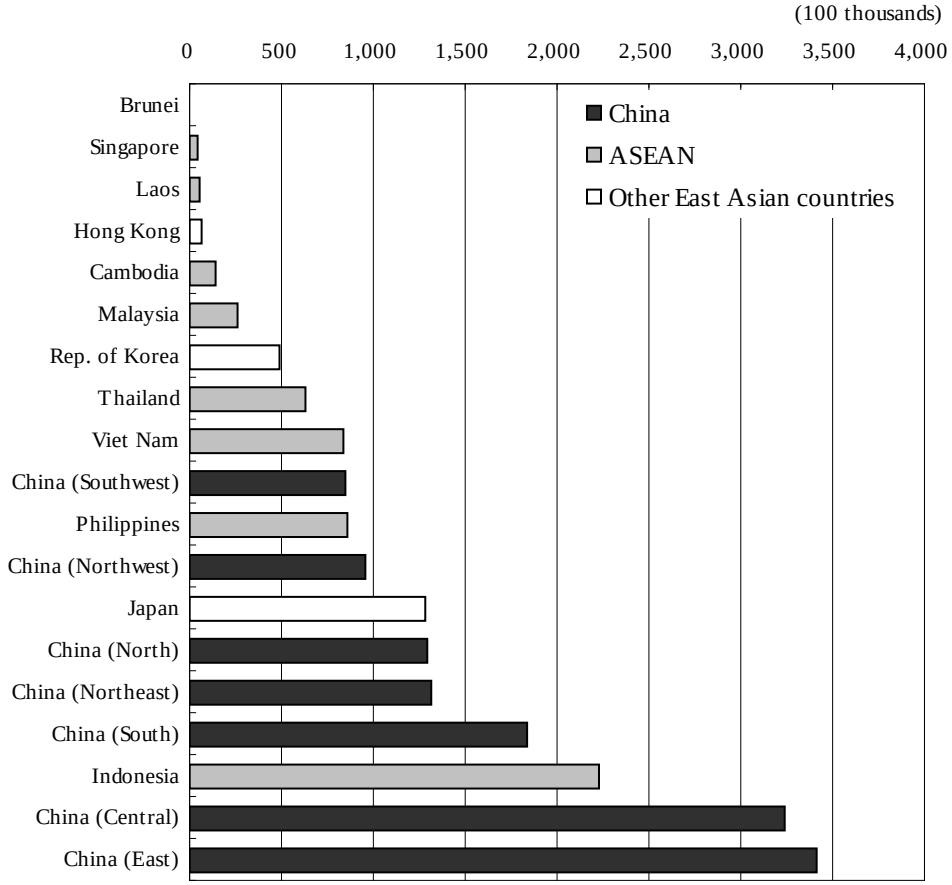
comparable with or even larger than other individual East Asian countries. East China, Central China, and South China already have large GRP that could well accommodate multiple industrial agglomerations. Population size of each region in China is huge, presenting great potential to become even bigger also in economic size. It would thus make sense to separate China into regions and analyze the nature of production networks and industrial agglomerations.

Figure 4. GRP of Regions within China and GDP of East Asian Countries in 2006



Source: Authors' calculation based on the data from World Development Indicators Online and China Statistical Yearbook 2007.

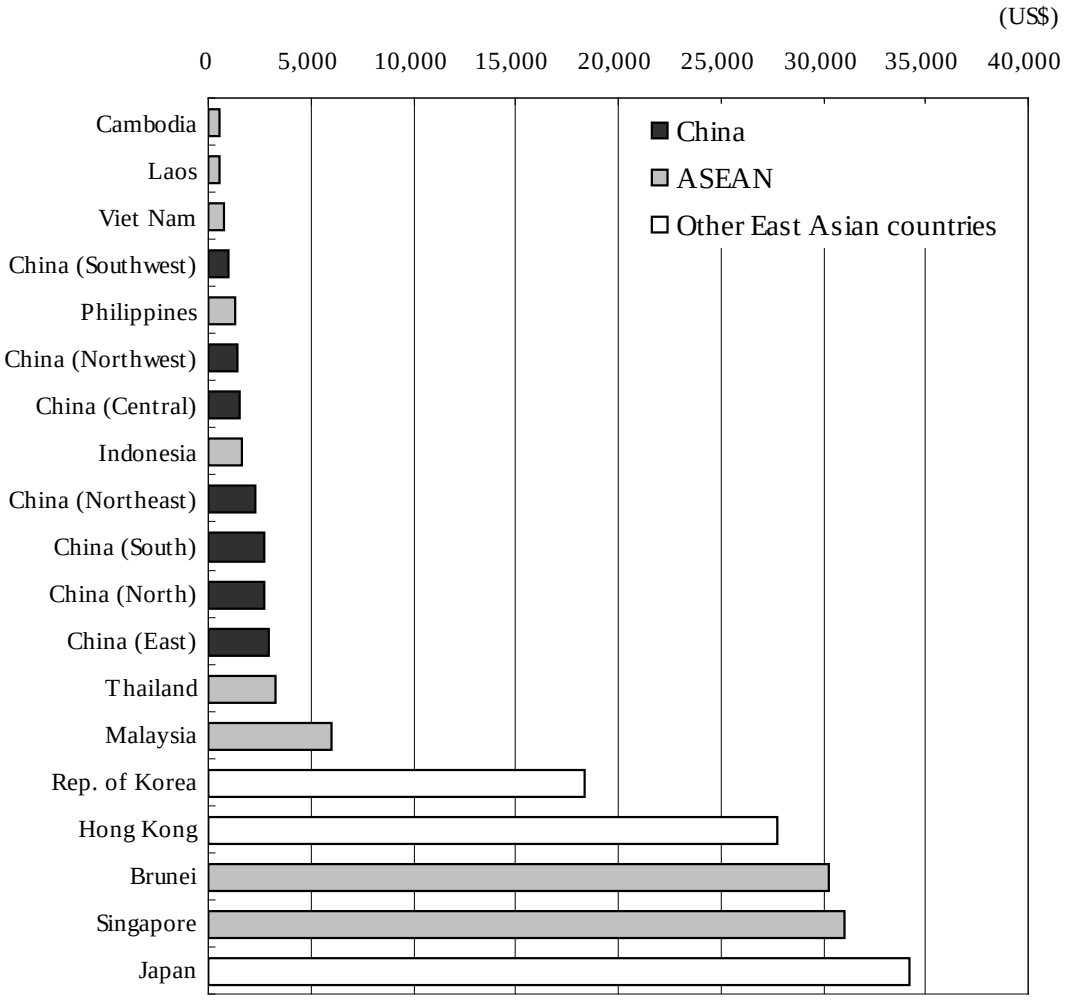
Figure 5. Total Population of Regions within China and East Asian Countries in 2006



Source: Authors' calculation based on the data from World Development Indicators Online and China Statistical Yearbook 2007.

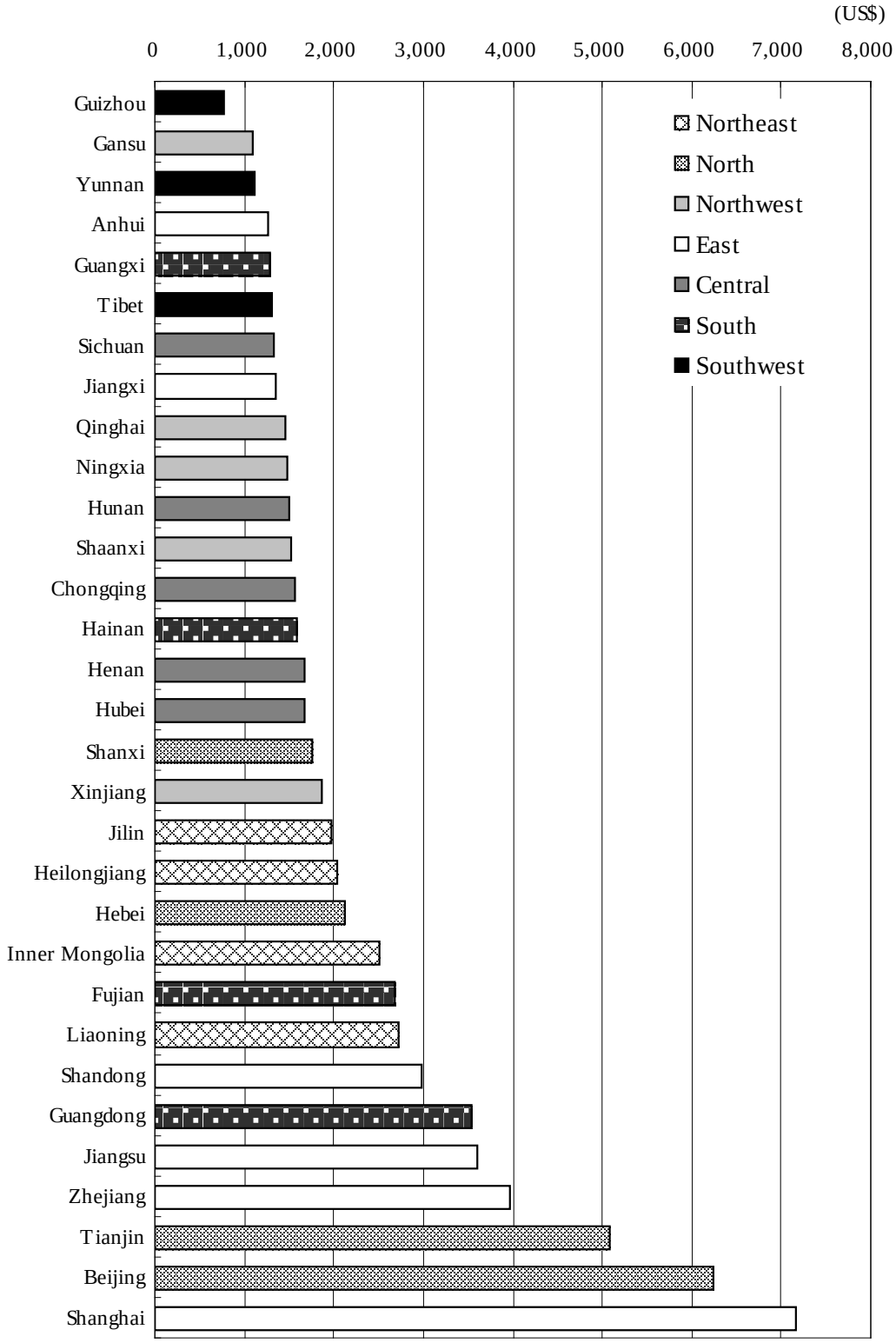
The second checkpoint is income levels. Figure 6 tabulates per capita GRP of regions within China and per capital GDP of East Asian countries. There are huge income-level gaps in East Asia, which suggests the existence of ample room for production fragmentation utilizing different location advantages. Substantial income-level gaps are observed even among ASEAN countries. Income gaps among regions within China may seem to be small. However, if we take the data of GRP at the provincial level, income gaps are also substantial (Figure 7). These suggest that production fragmentation among countries in ASEAN and among regions within China may also develop to some extent.

Figure 6. Per capita GRP of Regions within China and Per capita GDP of East Asian Countries in 2006



Source: Authors' calculation based on the data from World Development Indicators Online and China Statistical Yearbook 2007.

Figure 7. Per capita GRP in China in 2006: By Province



Source: Authors' calculation based on the data from China Statistical Yearbook 2007.

The third checkpoint is the prospects of economic integration. One obvious difference between China and ASEAN is in the potential of internal factor mobility. Although the Chinese economy used to be "lumpy" (Courant and Deardorff, 1992) in the sense that imperfect mobility of productive factors generated uneven factor prices across regions within a country, economic integration across regions seems to be significantly advanced by infrastructure development, notably the construction of highway networks, and the introduction of well-organized policy for West China development. China is a well-unified country basically with identical language, common historical and cultural background, and abundant human capital. Compared with ASEAN that consists of independent countries with different languages and diversified backgrounds separated by national borders, the Chinese economy has much larger potential to be a well-integrated economy. The implication for the participation in production networks by peripheries may not be so straightforward in this sense. New economic geography tells us that the reduction in trade cost may allow economic activities to move from the core to the periphery or rather the opposite in which the hollowing-out of the periphery may occur with further agglomeration of economic activities. The balance between agglomeration forces and dispersion forces would be crucial when we consider the possibility of narrowing development gaps within China.

Now let us start checking international trade data in order to grasp the overall picture of international production networks for the whole East Asia. Table 1 presents the pattern of intra-regional machinery exports from East Asian countries in 1993-2006. The proportion of machinery exports in total exports, particularly that of machinery parts & components exports, is a good indicator for judging the degree of participation in international production/distribution networks. In the process of joining in the networks, though both exports and imports of machineries increase, the export side changes much more drastically. Countries/economies are grouped into four: China, ASEAN4 (the Philippines, Indonesia, Thailand, and Malaysia), NIEs3 (Korea, Hong Kong, and Singapore), and Japan. The left part of the table reports values of total exports to the world in 1993, 2000, and 2006 for each country/country group. As for intra-East Asian exports, in addition to values of exports for three points in time, intra-East Asia's shares of total exports to the world, commodity composition, shares of each country/country group in intra-East Asian total exports, and annual average growth

rates in nominal prices are tabulated. Machineries here include HS84-92, i.e., general machinery, electric machinery, transport equipment, and precision machinery. Machinery products are further classified into machinery parts & components and machinery finished products.[3]

First and foremost, shares of intra-East Asian exports in the total exports to the world already reached a high level as of 1993, particularly in machinery parts & components, and steadily increased during the last decade with the exception of China. As of 2006, every country/country group had about 50% or more share of intra-East Asian exports in the total machinery parts & components exports to the world. For machinery finished products, on the other hand, inter-regional exports occupied a substantial share of around 65-75%. China caught up with other East Asian countries during the last decade, in terms of its trade pattern; intra-East Asian exports of machinery parts & components reached 53% by 2000 and gradually declined afterward, and inter-regional exports of machinery finished products increased its share from 44% in 1993 to 75% in 2006. As for ASEAN4, the shares of intra-East Asian exports increased from about 54% in 1993 to about 65% in 2006 for machinery parts & components while the shares of inter-regional exports remained dominant, around 60-65%, for machinery finished products.

Commodity composition figures clearly indicate active participation of respective East Asian countries in international production networks developed across the region. As seen in the proportion of machinery exports in the total intra-East Asian exports, particularly that of machinery parts & components exports, Japan was already a key country as of 1993, and NIEs3 became significant players in East Asian production networks by 2000. China is rapidly catching up with other East Asian countries, enhancing the proportion of machinery exports. ASEAN4 also grew up as active players particularly in transactions of machinery parts & components.[4]

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[3] For the definition of "machinery parts & components" and "machinery finished products" based on the HS classification, see Ando and Kimura (2005).

[4] Note that exports of machinery parts & components may be magnified to some extent by multi-layered trade; same parts & components may be traded again and again in production/distribution networks. Yi (2003) points out such a possibility of double- or triple-counting in parts & components trade. Also note that exports from ASEAN4 (NIEs3) include trade among ASEAN4 (NIEs3) countries.

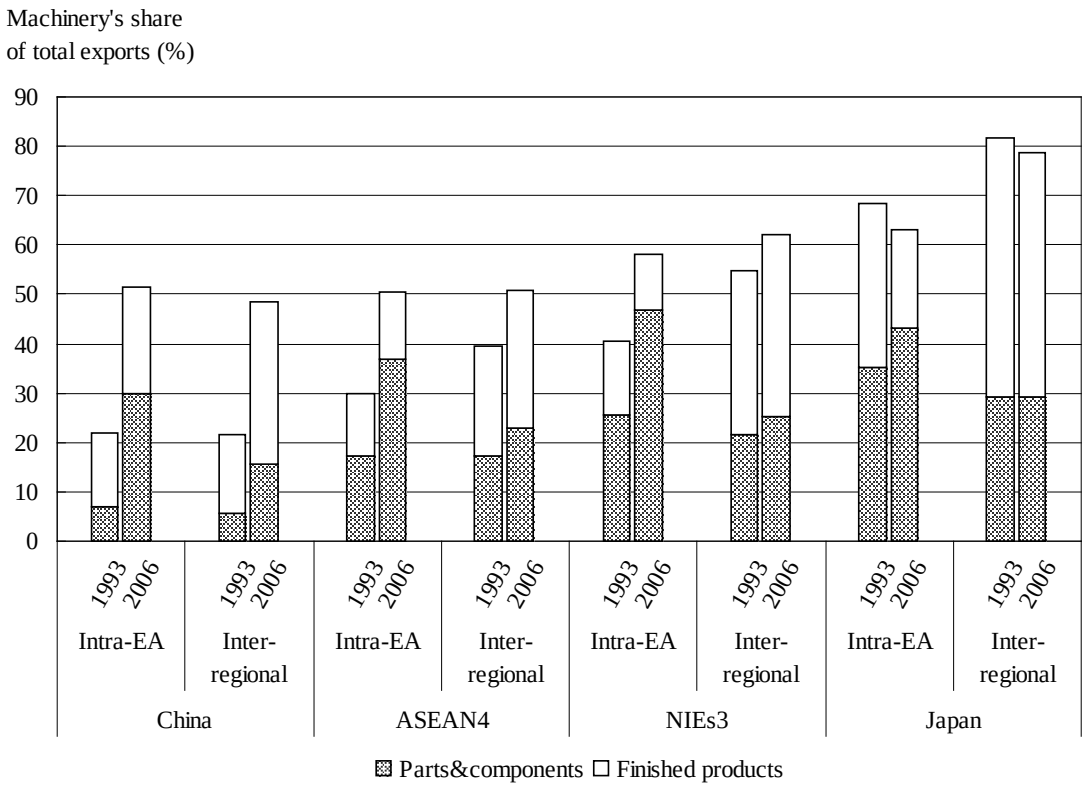
Table 1. Intra-East Asian Exports: By Country/Country Group

	Total exports to the world			Intra-East Asian exports												
	Export value (millions US$)			Export value (millions US$)			Share of total exports to the world (%)			Commodity composition (%)			Share in intra-East Asian total exports (%)			Annual average export growth 1993-2006 (%)
	1993	2000	2006	1993	2000	2006	1993	2000	2006	1993	2000	2006	1993	2000	2006	
China																
Machinery products	34,676	146,154	465,227	20,220	64,139	160,818	58.3	43.9	34.6	22.0	36.4	51.5	11.8	20.0	29.5	17.3
Parts&components	10,350	59,822	192,720	6,529	31,392	93,748	63.1	52.5	48.6	7.1	17.8	30.0	7.2	14.9	24.9	22.7
Finished products	24,326	86,332	272,507	13,691	32,747	67,070	56.3	37.9	24.6	14.9	18.6	21.5	16.9	29.9	39.9	13.0
All commodities	158,212	395,289	942,454	91,723	176,288	312,546	58.0	44.6	33.2	100.0	100.0	100.0	23.4	28.4	31.8	9.9
ASEAN4																
Machinery products	47,484	149,627	210,016	22,326	71,445	113,504	47.0	47.7	54.0	29.7	50.6	50.6	13.0	22.3	20.8	13.3
Parts&components	23,924	89,149	126,305	12,982	50,768	82,399	54.3	56.9	65.2	17.3	35.9	36.7	14.4	24.1	21.9	15.3
Finished products	23,560	60,478	83,711	9,344	20,677	31,105	39.7	34.2	37.2	12.4	14.6	13.9	11.5	18.8	18.5	9.7
All commodities	138,851	286,378	414,554	75,105	141,237	224,244	54.1	49.3	54.1	100.0	100.0	100.0	19.2	22.7	22.8	8.8
NIEs3																
Machinery products	87,288	184,832	272,472	35,490	71,740	129,238	40.7	38.8	47.4	40.4	52.4	58.3	20.7	22.4	23.7	10.5
Parts&components	42,845	101,932	161,912	22,535	50,628	104,077	52.6	49.7	64.3	25.7	37.0	46.9	25.0	24.0	27.6	12.5
Finished products	44,443	82,900	110,559	12,955	21,112	25,161	29.1	25.5	22.8	14.8	15.4	11.3	15.9	19.2	15.0	5.2
All commodities	182,450	307,097	452,314	87,763	136,969	221,785	48.1	44.6	49.0	100.0	100.0	100.0	22.4	22.0	22.6	7.4
Japan																
Machinery products	279,343	358,357	381,540	93,416	112,958	141,588	33.4	31.5	37.1	68.3	67.7	63.1	54.5	35.3	26.0	3.3
Parts&components	114,365	178,389	185,658	48,152	77,791	96,755	42.1	43.6	52.1	35.2	46.6	43.1	53.4	36.9	25.7	5.5
Finished products	164,978	179,968	195,882	45,264	35,167	44,833	27.4	19.5	22.9	33.1	21.1	20.0	55.7	32.1	26.7	-0.1
All commodities	364,156	469,806	528,846	136,790	166,953	224,468	37.6	35.5	42.4	100.0	100.0	100.0	35.0	26.9	22.8	3.9

Notes: All values are calculated at constant prices (constant 2000 US$; deflated by the US's WPI from World Development Indicator Online). Note that (i) "East Asia" here includes China, ASEAN4 (the Philippines, Indonesia, Thailand, and Malaysia), NIEs3 (Korea, Hong Kong, and Singapore) and Japan, (ii) we use "mirror" data, i.e., import data, from the standpoint of reliability, because country of origin is more closely verified due to tariff regulations although final destination may not be known at time of export, (iii) data for Singapore's imports from Indonesia, which only have been officially reported since 2003, are not included, (iv) data for the Philippines' imports, which only have been reported according to the HS classification since 1996, are replaced by data for exports to the Philippines adjusted by the c.i.f. / f.o.b. ratio, and (v) since the annual data at the HS six-digit level below $500 (current US$) are not reported before 2000, trade flows below $500 are treated as if there was no trade at all for all the years in the sample.
Source: Authors' calculation based on the data from UN Comtrade (HS 1992, six-digit).

As is apparent from Figure 8, as of 2006, more than the half of both intra-East Asian exports and inter-regional exports are accounted for by machineries for every country/country group of the region except for China's inter-regional exports.[5] It should be noted, however, that a substantial share of intra-East Asian machinery exports are of parts & components, unlike inter-regional machinery exports. Furthermore, for both China and ASEAN4, increases in the machinery's shares of intra-East Asian exports during the last decade are attributed mainly to rapidly increasing shares of machinery parts & components. These facts confirm the development of East Asian production networks with active participation of countries in the region.

Figure 8. Commodity Composition of Intra-East Asian and Inter-Regional Exports: By Country/Country Group



Source: Authors' calculation based on the data from UN Comtrade (HS 1992, six-digit).

[5] The contrast with other parts of the world is sharp. In Latin America, only Mexico and Costa Rica participate in international production networks in the sense that the proportion of machinery exports in the total exports is fairly large. Eastern Europe countries are also presenting an evolutionary pattern though networks do not cover many countries. See Ando and Kimura (2005).

Shares of each country/country group in intra-East Asian total exports have also significantly changed since the beginning of the 1990s (see Table 1 again). While Japan's share in intra-East Asian total machinery exports dropped from 55% in 1993 to 26% in 2006 and NIEs3's share was kept at around one-fourth, China and ASEAN4 no doubt becomes major players in East Asian production networks. The most drastic changes are found for China; China's share in intra-East Asian total machinery exports was merely 12% in 1993 and explosively expanded up to 20% in 2000 and 30% in 2006. ASEAN4's share reached 22% in 2000 though slightly declined after that.

These changes are confirmed by annual average real growth rates in 1993-2006. Growth rates of intra-East Asian machinery exports are considerably high, compared with growth rates of GDP. Annual average growth rates of intra-East Asian machinery exports from China are truly amazing; 17% for machinery products as a whole and 23% for machinery parts & components.

4. Comparison of Networking Patterns between China and ASEAN

This section examines regional diversity in the performance of intra-East Asian machinery exports within China, comparing with cross-country diversity within ASEAN. As for China's intra-East Asian machinery exports at the region level, this paper utilizes customs-based international trade data obtained from World Trade Atlas, which is aggregated into seven regions of interest.[6] Since internal transactions within China cannot be captured by international trade data, intra-ASEAN trade is excluded from the analysis so as to ensure the comparability with the region-level China's exports. After outlining regional and cross-country trends of intra-East Asian machinery exports for China and ASEAN, respectively, the following subsections look further into regional/cross-country diversity in export performance in three dimensions: the extensive and intensive margins of export growth, the transformation of export structure, and the overlap of export product bundles between regions/countries.

[6] See the Appendix for regional classification of 41 customs located in China. As for the map of all the ports of entry in China, see the web page of China Customs (http://www.customs.gov.cn/tabid/3173/Default.aspx).

4.1. Diversity in Intra-East Asian Machinery Exports

Table 2 presents the overall pattern of intra-East Asian machinery exports from China and ASEAN in 2006 by region and country, respectively. For intra-East Asian exports from China, export destination countries here include Taiwan as well as ASEAN4, NIEs3, and Japan; for intra-East Asian exports from ASEAN, destinations include China, NIEs3, Japan, but not Taiwan.[7] In addition to values of exports, machinery's shares in total exports, shares by region/country, and the composition of machinery exports are tabulated.[8]

Table 2. Intra-East Asian Exports from China/ASEAN in 2006: By Region/Country

	All commodities	Machinery products				
	Export value (millions US$)	Export value (millions US$)	Share of total exports (%)	Share by region/ country (%)	Composition of machinery exports (%)	
					Parts& components	Finished products
China, total	374,187	206,693	55.2	100.0	63.5	36.5
Northeast region	16,753	4,751	28.4	2.3	58.2	41.8
North China	30,056	14,196	47.2	6.9	60.4	39.6
Northwest region	668	121	18.1	0.1	52.0	48.0
East China	151,118	77,686	51.4	37.6	71.8	28.2
Central China	2,968	894	30.1	0.4	80.1	19.9
South China	171,896	109,000	63.4	52.7	58.1	41.9
Southwest region	729	46	6.3	0.0	47.1	52.9
ASEAN, total	226,488	109,038	48.1	100.0	75.6	24.4
Brunei	3,666	2	0.1	0.0	40.8	59.2
Cambodia	679	2	0.3	0.0	4.8	95.2
Indonesia	39,472	3,180	8.1	2.9	58.3	41.7
Malaysia	39,642	19,248	48.6	17.7	73.2	26.8
Philippines	17,675	13,220	74.8	12.1	86.4	13.6
Singapore	77,382	53,555	69.2	49.1	80.7	19.3
Thailand	38,193	17,962	47.0	16.5	57.8	42.2
Viet Nam	9,779	1,869	19.1	1.7	74.8	25.2

Notes: All values are at current prices. Note that (i) Laos and Myanmar are not included in ASEAN due to data unavailability, and (ii) since transactions inside China cannot be captured by international trade data, intra-ASEAN trade is excluded to ensure the comparability with Chinese export data at the region level.
Source: Authors' calculation based on the Chinese export data from World Trade Atlas (HS 2002; six-digit) and the ASEAN export data from UN Comtrade (HS 1996, six-digit).

[7] Note that Taiwan's export and import statistics are not reported in UN Comrade from which the ASEAN export data are obtained.
[8] As in the previous section, machinery products including HS84-92 are grouped into parts & components and finished products as in Ando and Kimura (2005).

While the proportion of machinery exports in the total intra-East Asian exports from China as a whole has reached 55%, the machinery's share ranges from 6% for the southwest region to 63% for South China. Similarly, the machinery's share is 48% for ASEAN as a whole, but ranges from less than 1% for Brunei to 75% for the Philippines. The degree of participation in East Asian production/distribution networks greatly varies across regions/countries. Overall, a large share of total merchandise exports seems to be more likely to be accounted for by machineries for more advanced economies in China and ASEAN in terms of the level of per capita GRP/GDP. As for the composition of machinery exports, parts & components make up a larger share than finished products for every part of both China and ASEAN, with the exceptions of less advanced economies such as the southwest region of China, Cambodia, and Brunei.

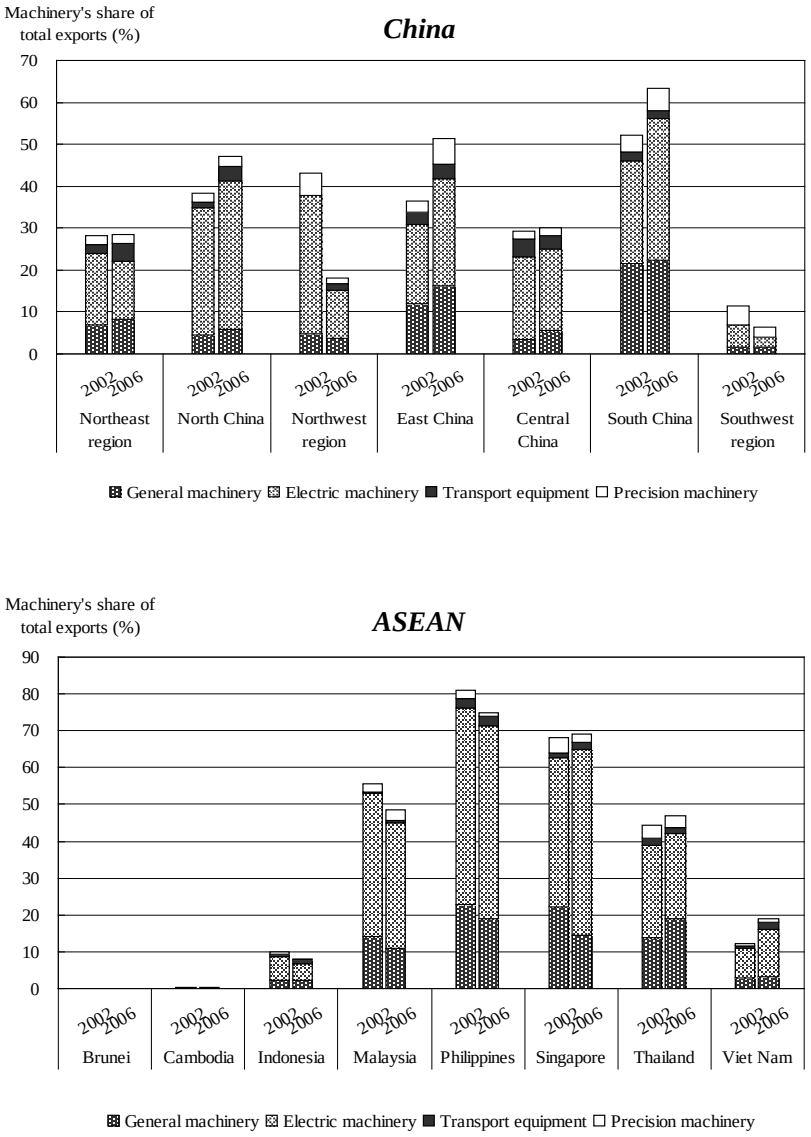
Intra-East Asian machinery exports from China are dominated by South China and East China, which account for 53% and 38% of those, respectively. In the case of ASEAN, on the other hand, Singapore is a leading exporter, though a certain portion of exports would be re-exports in nature, followed by Malaysia, Thailand, and the Philippines, which also account for a substantial share of intra-East Asian machinery exports from ASEAN as a whole. Yet, intra-East Asian machinery exports from less advanced economies in China and ASEAN are still negligible in amount as of 2006.

Figure 9 presents more detailed composition of intra-East Asian machinery exports for respective regions/countries within China/ASEAN in 2002 and 2006. As observed in Table 2, machinery industries account for a substantial share of intra-East Asian merchandise exports for every part of both China and ASEAN, except for the southwest region of China, Brunei, Cambodia, and Indonesia.

It is striking that machinery's shares of total merchandise exports for South China, East China, and North China rapidly increased while those for the northwest and southwest regions of China declined from 2002 to 2006. A region with a larger share of intra-East Asian machinery exports initially in 2002 has further enhanced its capacity to export machinery products, leading to the increasing share of machineries. Meanwhile, the northwest and southwest regions seem to be more specialized in exporting goods of industries other than machinery industries. In the case of ASEAN, although Vietnam has presented a notable catching-up, cross-country differences in the relative importance of machineries have also mostly remained for the last several years.

These results can be interpreted as indicating large differences in the degree of participation in international production networks among regions/countries within China/ASEAN.[9]

Figure 9. Composition of Intra-East Asian Machinery Exports from China/ASEAN: By Region/Country



Source: Authors' calculation based on the Chinese export data from World Trade Atlas (HS 2002; six-digit) and the ASEAN export data from UN Comtrade (HS 1996, six-digit).

[9] To keep symmetry with the Chinese case, the lower part of Figure 9 excludes intra-ASEAN exports. However, including intra-ASEAN exports does not change machinery shares of total exports much except Indonesia. In Indonesia's case, machinery exports to Singapore push up the shares by 8-10 points.

In addition, electric machinery plays an important role for every part of both China and ASEAN, reflecting the characteristics of the industry suitable for production fragmentation. However, the shares of machinery subsectors in intra-East Asian machinery exports vary by region/country.

4.2. Extensive versus Intensive Margins of Export Growth

The range of exported products also widely varies across regions/countries within China/ASEAN. Table 3 highlights that, as of 2006, the number of exported products ranges from 113 for the southwest region to 1,084 for South China within China and from 45 for Cambodia to 1,023 for Singapore within ASEAN. At the aggregate level, compared to the maximal possible number of product lines (1,172 for China and 1,174 for ASEAN), a very wide range of products, 1,133 and 1,135 products, are exported from China and ASEAN, respectively.[10] East China, South China, and Singapore export more than 1,000 product lines that cover most of the varieties for China and ASEAN total, and regional/cross-country diversity of exported products within China/ASEAN supplements the coverage.

In addition to the number of exported products, Table 3 records values and annual average real growth rates of intra-East Asian machinery exports in 2002-2006. Compared with ASEAN, a drastic increase in intra-East Asian machinery exports from China is obvious at a glance. Although export values are almost the same at the aggregate level as of 2002, intra-East Asian machinery exports from China as a whole expanded three times in just four years, and the figure for China became twice larger than that for ASEAN as of 2006. More importantly, every region within China achieved annual growth of more than 16%, as contrasted with the case of ASEAN in which Cambodia experienced negative growth.

[10] The maximal possible numbers of product lines are slightly different between China and ASEAN because trade data are reported according to different versions of HS classification.

Table 3. Export Growth Decomposition for Intra-East Asian Machinery Exports from China/ASEAN: By Region/Country

	Export value (millions US$)		Annual average export growth 2002-06 (%)	The number of exported products (max: 1172 for China; 1174 for ASEAN)		Export growth contribution (%)		
	2002	2006		2002	2006	Existing	Disappear	New
China, total	70,738	206,693	30.7	1,110	1,133	99.9	0.0	0.1
Northeast region	2,615	4,751	16.1	648	748	87.7	-0.5	12.9
North China	4,651	14,196	32.2	850	917	97.4	-0.1	2.7
Northwest region	61	121	18.4	129	167	84.4	-9.3	24.9
East China	19,537	77,686	41.2	1,044	1,082	99.9	0.0	0.1
Central China	320	894	29.3	424	524	94.4	-1.5	7.1
South China	37,955	109,000	30.2	1,041	1,084	99.9	0.0	0.1
Southwest region	17	46	27.5	108	113	17.1	-9.8	92.6
ASEAN, total	71,094	109,039	11.3	1,131	1,135	99.9	-0.1	0.2
Brunei	1	2	12.1	44	138	-3.3	-98.3	201.6
Cambodia	2	2	-2.9	53	45	-195.7	-515.0	610.7
Indonesia	2,919	3,180	2.2	749	811	125.2	-38.5	13.3
Malaysia	17,116	19,248	3.0	880	856	102.4	-3.9	1.5
Philippines	12,351	13,220	1.7	638	584	106.4	-7.4	1.0
Singapore	27,275	53,555	18.4	1,024	1,023	98.6	-0.1	1.5
Thailand	10,669	17,962	13.9	871	943	99.4	-0.2	0.7
Viet Nam	761	1,869	25.2	404	544	90.8	-2.3	11.5

Notes: All values are calculated at constant prices (constant 2006 US$; deflated by exporter's WPI/CPI from International Financial Statistics Online). The maximal possible numbers of exported products are different between China and ASEAN due to different versions of HS classification.
Source: Authors' calculation based on the Chinese export data from World Trade Atlas (HS 2002; six-digit) and the ASEAN export data from UN Comtrade (HS 1996, six-digit).

Along the line of Evenett and Venables (2002) and others, the intra-East Asian machinery export growth is decomposed into changes in the composition of products as follows:

$$\frac{\sum_j V^i_{j,2006} - \sum_j V^i_{j,2002}}{\sum_j V^i_{j,2002}} = \frac{\sum_{j\in E^i}(V^i_{j,2006} - V^i_{j,2002})}{\sum_j V^i_{j,2002}} - \frac{\sum_{j\in D^i} V^i_{j,2002}}{\sum_j V^i_{j,2002}} + \frac{\sum_{j\in N^i} V^i_{j,2006}}{\sum_j V^i_{j,2002}} \quad ,$$

where V^i_{jt} is country/region i's exports of product j in year t, and E^i, D^i, and N^i are the sets of existing, disappearing, and new products exported from country/region i, respectively. The most right three columns of Table 3 record the share of contribution of products in each category to the intra-East Asian machinery export growth.

An increase in intra-East Asian machinery exports has been almost entirely driven by the larger volume of existing products; the export growth contribution of existing

products, i.e., intensive margin, is 99.9% at the aggregate level both for China and ASEAN.[11] It should be noted, however, that the growth contribution of newly exported products, i.e., extensive margin, is overwhelmingly large for economies with a limited number of exported products as well as a smaller value of exports as of 2002, such as the southwest region of China, Cambodia, and Brunei. Newly exported products also play a considerable role in the export growth for the northwest and northeast regions of China, Indonesia, and Viet Nam.[12] Latecomers expand intra-East Asian machinery exports through the birth of newly exported products and are gradually catching up with forerunners to some extent in terms of a wider range of exported products; however, unambiguously large regional/cross-country disparities still exist in the value of intra-East Asian machinery exports within China/ASEAN. Although Viet Nam achieved the highest annual average growth rate among ASEAN countries and the growth rate of Brunei is slightly higher than the ASEAN average, the disparities in the value of intra-East Asian machinery exports are hardly narrowing during the last several years for both cases of China and ASEAN.

4.3. Diversification versus Specialization of Export Product Composition

Next, whether or not export shares are equally distributed across products is examined, regardless of the birth and death of products. The degree of the specialization of product composition of intra-East Asian machinery exports is measured by calculating Gini coefficients as follows:

$$Gini_t^i = 1 - 1/n \sum_k (cumshare_{k-1,t}^i + cumshare_{kt}^i) \quad ,$$

where there are n products with a product's rank k in the ascending order in terms of export shares, and $cumshare^i_{kt}$ is the cumulative share of exports of the k-th product in the total value of intra-East Asian machinery exports from country/region i in year t. A Gini coefficient of zero indicates that export shares are equally distributed across

[11] Amiti and Freund (2008) also find that most of China's export growth occurred in the intensive margin, for both its exports to the U.S. and to the world, by decomposing its export growth into the extensive and intensive margin.

[12] Hummels and Klenow (2005) find that the extensive margin accounts for 60 percent of the greater exports of larger economies relative to smaller economies in their sample of 126 exporting countries, which is suggestive of the importance of the extensive margin growth for latecomer economies.

products. A larger coefficient corresponds to a higher degree of the specialization of export product composition, and an increase in the coefficient indicates an increase in the degree of specialization. Table 4 reports Gini coefficients not only for the whole sample of machinery products actually exported but also for top 75% and bottom 75% of the sample in terms of export shares.

Table 4. Gini Coefficient for The Product Composition of Intra-East Asian Machinery Exports from China/ASEAN: By Region/Country

	All machinery products		Top 75%		Bottom 75%	
	2002	2006	2002	2006	2002	2006
China, total	0.90	0.91	0.54	0.57	0.87	0.88
Northeast region	0.93	0.89	0.54	0.43	0.91	0.87
North China	0.93	0.94	0.61	0.67	0.90	0.90
Northwest region	0.91	0.94	0.57	0.49	0.88	0.93
East China	0.88	0.91	0.54	0.64	0.85	0.87
Central China	0.93	0.92	0.62	0.64	0.90	0.88
South China	0.92	0.93	0.54	0.48	0.90	0.92
Southwest region	0.92	0.90	0.51	0.36	0.90	0.90
ASEAN, total	0.92	0.93	0.58	0.62	0.90	0.91
Brunei	0.87	0.86	0.97	0.45	0.83	0.83
Cambodia	0.79	0.79	0.36	0.48	0.77	0.75
Indonesia	0.90	0.92	0.44	0.46	0.88	0.90
Malaysia	0.95	0.94	0.60	0.62	0.92	0.92
Philippines	0.97	0.97	0.57	0.44	0.96	0.97
Singapore	0.94	0.96	0.63	0.60	0.92	0.94
Thailand	0.92	0.93	0.48	0.54	0.90	0.91
Viet Nam	0.92	0.93	0.52	0.50	0.90	0.92

Source: Authors' calculation based on the Chinese export data from World Trade Atlas (HS 2002; six-digit) and the ASEAN export data from UN Comtrade (HS 1996, six-digit).

For both China and ASEAN at the aggregate level, the Gini coefficients for the product composition of intra-East Asian machinery exports remained unchanged for the whole sample. If we focus on the top 75% of the sample, the coefficients slightly increased from 2002 to 2006, indicating enhanced specialization. A smaller number of products have occupied a larger portion of intra-East Asian machinery exports both for China and ASEAN.[13]

[13] Amiti and Freund (2008) also highlight enhanced specialization in China's exports to the U.S.

However, the specialization of export product composition is not uniformly observed for every part of China/ASEAN. In the case of China, the Gini coefficients decreased for the northeast and southwest regions; if focusing only on the top 75% of the sample, the coefficients also decreased for the northwest region. This pattern of changes in export product composition indicates the diversified range of exported products non-negligible in amount for latecomer regions, which is consistent with the considerable export growth contribution of newly exported products revealed in the last subsection. In the case of ASEAN, on the other hand, if focusing only on the top 75%, the coefficients decreased for Brunei and Viet Nam but not for other latecomer countries.

Even when the top one-fourth products in terms of export share are excluded, the regional/cross-country variations in specialization/diversification pattern of export product composition do not substantially differ from the whole sample. Furthermore, the coefficients still remain at a high level for respective regions/countries as well as for China/ASEAN as a whole, which means that the major products occupying large shares do not much pull up the degree of the specialization of export product composition.

4.4. Similarity versus Dissimilarity of Export Product Bundle

To directly measure the extent to which export product bundles are overlapping between regions/countries within China/ASEAN, the Export Similarity Index (ESI) proposed by Finger and Kreinin (1979) is utilized. ESI is defined as

$$ESI_t^i = 100\sum\nolimits_j \min(s_{jt}^i, s_{jt}^*) \quad ,$$

where s_{jt}^i is the share of product j in the total value of intra-East Asian machinery exports from region/country i in year t, and * denotes a reference region/country.[14] Export product bundles of South China and Singapore are used as reference for China and ASEAN, respectively, since they have been leading players in intra-East Asian machinery exports. The index is bounded by zero when region/country i and a

and to the world, by calculating the Gini coefficients for their product compositions.

[14] Wang and Wei (2008) calculate ESI at the highly-detailed city level and investigate the factors behind cross-city differences in sophistication of export product structure in China. While Wang and Wei use G-3 (Japan, the US, and EU) as a reference, this paper directly analyzes the diversity of export product bundles among regions within China, using its leading region as a reference.

reference region/country export no products in common, i.e., no overlap, and 100 when their exports are identically distributed across products. Note that the index incorporates information on both product penetration and its market share.

Table 5 reports each region/country's export similarity with South China/Singapore as a reference region/country for intra-East Asian machinery exports in 2002 and 2006. The *ESI* figures greatly vary across regions/countries within China/ASEAN, which indicates large regional/cross-country differences in the product bundle of intra-East Asian machinery exports. As of 2006, the index ranges from 6.4 for the northwest region to 61.8 for East China within China and from 0.9 for Cambodia to 56.8 for Malaysia within ASEAN.

Table 5. Export Similarity Index for The Product Composition of Intra-East Asian Machinery Exports from China/ASEAN: By Region/Country

	All machinery products						Machinery parts&components					
	All		Top 90%		Top 75%		All		Top 90%		Top 75%	
	2002	2006	2002	2006	2002	2006	2002	2006	2002	2006	2002	2006
China (South China as a reference)												
Northeast region	35.6	38.6	34.2	37.1	33.9	34.9	48.2	47.6	46.7	45.7	47.0	45.6
North China	32.5	38.2	29.7	35.6	23.8	30.3	33.2	43.6	29.2	39.8	21.1	35.8
Northwest region	5.7	6.4	2.9	3.3	2.0	0.8	6.5	7.3	2.8	3.8	1.7	0.0
East China	56.8	61.8	54.8	60.2	52.6	59.2	58.7	63.2	56.6	61.4	51.4	60.0
Central China	13.2	21.4	8.9	18.6	4.5	15.1	13.5	25.9	8.6	22.9	3.1	21.5
Southwest region	6.4	24.5	3.4	24.0	0.0	22.2	11.4	33.2	9.2	34.3	0.0	27.9
ASEAN (Singapore as a reference)												
Brunei	6.3	5.7	4.2	2.4	0.0	0.0	4.9	6.1	1.1	3.9	0.0	0.0
Cambodia	1.8	0.9	0.3	0.6	0.0	0.0	1.7	0.9	0.0	0.5	0.0	0.0
Indonesia	20.9	16.1	17.1	12.6	12.5	7.1	23.4	12.2	19.4	7.9	12.5	0.0
Malaysia	43.0	56.8	40.4	56.5	39.2	58.9	49.5	58.9	47.4	59.4	46.4	58.7
Philippines	31.7	26.2	29.5	23.8	24.7	19.6	26.3	24.5	22.0	21.5	17.3	15.0
Thailand	39.9	41.7	37.5	40.0	35.4	37.4	48.0	53.8	45.7	52.2	43.7	49.9
Viet Nam	19.2	10.9	16.1	7.4	12.9	2.5	23.2	10.5	19.9	7.1	19.3	3.4

Note: Export Similarity Index is calculated using South China/Singapore as a reference region/country.
Source: Authors' calculation based on the Chinese export data from World Trade Atlas (HS 2002; six-digit) and the ASEAN export data from UN Comtrade (HS 1996, six-digit).

Not to be overlooked, however, is that the index increased from 2002 to 2006 for every region within China, which indicates that, despite regional differences in export performance revealed in the preceding subsections, the export product bundles of respective regions are catching up with South China, the leading exporting region in the country. From the standpoint of what they export with an overlap, regional trends of

intra-East Asian machinery exports within China become similar with each other.

In contrast, in the case of ASEAN, the indexes increased for Malaysia and Thailand with relatively high values of the indexes initially in 2002 while the indexes decreased over time for the other countries. Unlike with the regional comparison within China, the export product bundles of most countries within ASEAN are not catching up with Singapore, the leading exporting country, but becoming more skewed toward different products with reference to Singapore. Given the fact that Malaysia and Thailand as well as Singapore are relatively more advanced economies within ASEAN, what respective ASEAN countries export seem to specialize in a certain range of machinery products according to the level of economic development level, as opposed to the enhanced similarity in export product bundle among regions within China.

The index slightly decreases if we focus only on top 90% or 75% major exported products in terms of export shares since exports of products negligible in amount are excluded. In addition, the figures are mostly higher for the export product bundle of machinery parts & components than for that of all the machinery products with the exception of the Philippines. Compared with finished products, the same product of machinery parts & components is more likely to be exported simultaneously from different regions/countries within China/ASEAN to other East Asian countries.

5. Conclusion

This paper examines the data of machinery exports by regions within China and countries in ASEAN and assesses the degree of participation in international production networks by regions/countries. The intuition of extended fragmentation theory helps understand similarities and differences between China and ASEAN in terms of the degree and the nature of production networking.

We find that China and ASEAN share a number of common elements. Both came into international production networks extended in East Asia with utilizing differences in location advantages from more industrialized countries. Notably, South China, East China, and North China as well as Singapore, Malaysia, Thailand, and others became

major players in East Asia-wide production networks, and industrial agglomerations also began to be formulated. Yet, substantial differences remain in the degree of participation in international production networks among regions within China and countries in ASEAN. How to utilize the mechanics of international production networks is crucial for both China and ASEAN to narrow development gaps.

We also find some notable differences between China and ASEAN. The speed of development of machinery industries is outstanding in China while the frontier of production networks does not seem to move much in ASEAN in the past several years. There are some signs indicating the convergence of machinery trade patterns across regions within China, particularly in our study with Gini coefficients and export similarity indices, while ASEAN rather seems to enhance the pattern of specialization. The economic logic of fragmentation looks to be better utilized in China than in ASEAN.

Policy implication for ASEAN is obvious. In order to activate production networks and capture trickle-down effects by latecomers, it is necessary to further reduce service link costs by constructing logistics infrastructure together with trade facilitation and to improve location advantages by developing economic infrastructure and industrial estates.

Economic dynamism and bold government measures are the strengths for China. Whether production fragmentation can accelerate narrowing development gaps or not, however, is a delicate issue. New economic geography suggests that a reduction in trade cost may lead to either more concentration or more dispersion of economic activities. To make sure that splendid economic growth is accompanied with narrowing disparity, policy support for West Development may need to be continued. Although this paper concentrates on analyzing international trade data, more detailed study on intra-China fragmentation seems to be necessary in order to understand the core-periphery dynamics.

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