Chapter 3
Production Networks in East Asia: What We Know So Far

Fukunari Kimura and Ayako Obashi

Abstract Production networks in East Asia, particularly in the manufacturing and machinery industries, are well recognized as the most advanced in the world, in terms of their magnitude, extensiveness, and sophistication. This chapter tries to link various economic studies on related topics, to see how much we understand about production networks in East Asia. After providing a brief overview of international trade statistics, this chapter reviews a number of academic papers concerning (i) the structure and mechanics of production networks, (ii) the conditions for production networks, and (iii) the properties and implications thereof.

Keywords Empirical studies of trade • Economic integration • Multinational firms • International business

3.1 East Asia Leading the World

East Asia has been leading the world in sustained economic growth for the past three decades.[1] The strength of the East Asian economies has resided in the unprecedented development of international production networks. After demonstrating strong recoveries from two massive economic crises and ultimately emerging stronger from each, East Asia has by now truly become the "Factory of the World." Moreover, most recently, its dependency on extra-regional demand has substantially lessened, due to the explosive expansion of its middle-income population.

The pattern of international division of labor and international trade in East Asia is no longer adequately explained by the textbook versions of international trade theories. The international division of labor is not by industry, but by production

[1] In this chapter, East Asia is defined as a region centering on Northeast and Southeast Asian countries.

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G. Wignaraja (ed.), *Production Networks and Enterprises in East Asia*, ADB Institute Series on Development Economics, DOI 10.1007/978-4-431-55498-1_3

process, which differs from a standard reading of comparative advantage models such as the Ricardian and the Heckscher–Ohlin varieties. Intra-industry trade based on the vertical division of labor also does not follow the formulation of the Helpman–Krugman intra-industry trade model with horizontal production differentiation (Helpman and Krugman 1985). What we observe is the fragmentation of production and the formation of industrial agglomerations.

Such production networks are particularly well developed in machinery industries, though they are observed elsewhere to some extent. Machines typically consist of a large number of parts and components, each of which is produced by diversified technologies and inputs. Machinery industries are thus particularly suited to the fragmentation of production.

Designers and coordinators of international production networks are primarily multinational enterprises (MNEs), not just from Japan; Republic of Korea; Taipei,China; Hong Kong, China; and other East Asian economies, but also from America, Europe, and the rest of the world. However, East Asian MNEs are particularly strong in machinery industries, and are well experienced in the fragmentation of production.

Developing East Asia presents novel development strategies. These economies aggressively utilize MNEs in an open setting and accept almost all sorts of such firms, which enables them to participate in international production networks and form industrial agglomerations. After this stage, local firms, entrepreneurs, and engineers increase their participation through their penetration into MNEs' production networks. These strategies are fundamentally different from the traditional infant industry protection model or strategies involving import-substituting foreign direct investment (FDI). They also differ from a simple hosting of exporting MNEs. Developing East Asia has much more effectively taken advantage of globalizing forces for its economic development than other developing regions in the world.

The formation of production networks in East Asia is a novel phenomenon that cannot fully be digested by our traditional ways of thought. However, we have already accumulated a number of theoretical and empirical studies that are directly or indirectly related to production networks. It seems at this moment worthwhile to compile various literatures, assessing what we have learned so far, and what we should investigate further. Through a selective survey, this chapter provides a broad picture of academic literature dealing with production networks in East Asia.

It starts by providing a brief data overview of production networks in East Asia.[2] Then it will classify papers into three categories: structure and mechanics of production networks, conditions for their existence, and properties and implications thereof. Our review is self-consciously subjective, trying to interpret the findings of existing studies in order to investigate the nature and characteristics of production networks in East Asia.

[2] As for the data overview of production networks, also see Athukorala (2005), Athukorala and Menon (2010), and Kimura (2006).

3.2 Overview

Before proceeding, we should briefly survey the significance and extension of production networks as seen from international trade statistics. In light of the fact that the machinery industry has the most sophisticated production networks in East Asia and worldwide, we focus on trade patterns of machinery parts and components, in comparison with those of finished machinery products.[3,4]

First and foremost, East Asian economies have expanded and strengthened transactions of machinery parts and components with intraregional partners to a greater extent than with outsiders. Table 3.1 provides summarized statistics of intraregional and extra-regional exports in East Asia (the Association of Southeast Asian Nations plus six other countries (ASEAN + 6)), compared with Europe (the 27 countries of the European Union (EU27)) and America (North American Free Trade Agreement (NAFTA) & Union of South American Nations (UNASUR)). Values of intraregional exports in 1994, 2000, and 2007, annual average export growth rates in 1994–2000 and 2000–2007, and the product composition of exports in 1994 and 2007 are reported on the left of the table. The corresponding figures for extra-regional exports are reported to the right. Intraregional exports as a proportion of total exports in 1994 and 2007 are reported in the rightmost column.

Table 3.1 highlights the increasing importance of machinery parts and components to transactions within East Asia. Along with the growing importance of machinery parts and components in the intraregional trade of manufactured goods, the importance of intraregional partners in East Asia's total exports of machinery parts and components has also increased.[5] In particular, the proportions of information and communications technology (ICT)-related parts and components in intraregional trade have remained notably high, and the intraregional share of exports of ICT-related parts and components has increased. This is clear evidence of the development of international production networks within East Asia especially. In addition, since 2000, East Asian countries have begun to increase intraregional exports not only of machinery parts and components but also of finished products, which indicates the growing importance of intraregional markets as an ultimate source of demand for their exports.

[3] As for the definition of machinery parts and components applied here, see Kimura and Obashi (2010).

[4] To quantify the extent of the international fragmentation of production, some empirical studies use data on outward/inward processing trade such as the US Offshore Assembly Programme and the European Union (EU) Processing Trade data. See Amador and Cabral (2009) for the detailed literature survey.

[5] The intraregional share has increased for the import side as well. See Kimura and Obashi (2010) for the detailed examinations on East Asia's trade structure and its changes.

Table 3.1 Intraregional and extra-regional exports by East Asia: comparison with Europe and America

	Intraregional exports							Extra-regional exports							Intra-regional share in exports to world	
	Value (million US$)			Annual average growth rate		Product composition		Value (million US$)			Annual average growth rate		Product composition		Product composition	
	1994	2000	2007	94–00	00–07	1994	2007	1994	2000	2007	94–00	00–07	1994	2007	1994	2007
				%	%	%	%				%	%	%	%	%	%
East Asia (ASEAN + 6)																
All manufactured goods	4,468	5,678	11,035	4	10	80	78	6,415	8,141	14,897	4	9	89	87	41	43
Machinery	2,579	3,513	6,607	5	9	46	47	4,278	5,494	9,266	4	8	59	54	38	42
Parts and components	1,405	2,301	4,292	9	9	25	30	1,669	2,307	3,314	6	5	23	19	46	56
(ICT-related goods)	816	1,585	2,433	12	6	15	17	844	1,308	1,310	8	0	12	8	49	65
Finished products	1,174	1,212	2,315	1	10	21	16	2,610	3,187	5,951	3	9	36	35	31	28
(ICT-related goods)	428	530	1,035	4	10	8	7	1,086	1,316	2,456	3	9	15	14	28	30
Other manufactured goods	1,889	2,165	4,428	2	11	34	31	2,136	2,646	5,631	4	11	30	33	47	44
Merchandise trade, total	5,585	7,099	14,106	4	10	100	100	7,233	9,227	17,166	4	9	100	100	44	45

Europe (EU27)																
All manufactured goods	11,846	14,213	25,837	3	9	80	79	5,820	6,979	12,953	3	9	84	85	67	67
Machinery	5,707	7,770	13,074	5	8	38	40	3,206	4,072	7,423	4	9	46	49	64	64
Parts and components	2,364	3,204	5,554	5	8	16	17	1,350	1,806	3,179	5	8	20	21	64	64
(ICT-related goods)	506	867	771	9	−2	3	2	293	521	501	10	−1	4	3	63	61
Finished products	3,343	4,566	7,520	5	7	23	23	1,856	2,266	4,244	3	9	27	28	64	64
(ICT-related goods)	752	1,378	1,636	11	2	5	5	285	525	583	11	1	4	4	73	74
Other manufactured goods	6,139	6,444	12,763	1	10	41	39	2,613	2,908	5,530	2	10	38	36	70	70
Merchandise trade, total	14,846	17,692	32,748	3	9	100	100	6,905	8,271	15,272	3	9	100	100	68	68
America (NAFTA & UNASUR)																
All manufactured goods	4,505	7,122	8,033	8	2	77	69	3,702	4,715	6,727	4	5	73	71	55	54
Machinery	2,829	4,637	4,883	9	1	49	42	2,255	3,095	3,765	5	3	45	40	56	56
Parts and components	1,389	2,271	2,130	9	−1	24	18	1,116	1,717	1,817	7	1	22	19	55	54
(ICT-related goods)	317	636	319	12	−9	5	3	470	836	556	10	−6	9	6	40	36
Finished products	1,440	2,366	2,752	9	2	25	24	1,139	1,379	1,948	3	5	23	21	56	59
(ICT-related goods)	327	720	733	14	0	6	6	372	499	325	5	−6	7	3	47	69

(continued)

Table 3.1 (continued)

	Intraregional exports							Extra-regional exports							Intra-regional share in exports to world	
	Value (million US$)			Annual average growth rate		Product composition		Value (million US$)			Annual average growth rate		Product composition		Product composition	
	1994	2000	2007	94–00	00–07	1994	2007	1994	2000	2007	94–00	00–07	1994	2007	1994	2007
	1994	2000	2007	%	%	%	%	1994	2000	2007	%	%	%	%	%	%
Other manufactured goods	1,676	2,485	3,150	7	3	29	27	1,446	1,619	2,962	2	9	29	31	54	52
Merchandise trade, total	5,819	9,237	11,584	8	3	100	100	5,038	6,120	9,439	3	6	100	100	54	55

Source: Kimura and Obashi (2010)

Note: All figures are calculated using export statistics for bilateral merchandise trade. Trade values are deflated by the consumer price index (CPI) in the US *ASEAN + 6* the Association of South-East Asian Nations plus six other countries, *EU27* the 27 countries of the European Union, *NAFTA* North American Free Trade Agreement, *UNASUR* Union of South American Nations

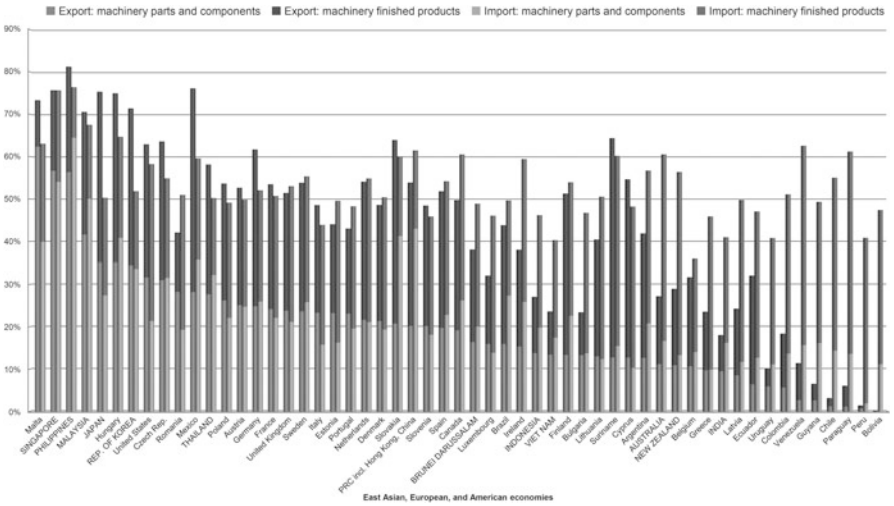

Fig. 3.1 Share of machinery in total exports and imports of manufactured goods, 2007. The *bars* are in descending order of the percentage of machinery parts and components in total exports of manufactured goods, from *left* to *right*. Note: All figures are calculated using export and import statistics for bilateral trade in manufactured goods. *PRC incl. HK* People's Republic of China including Hong Kong, China (Source: Kimura and Obashi 2010)

The formation of international production networks is not limited to the East Asian region, and such networks now stretch across an increasing number of countries.[6] Nonetheless, East Asian countries have played the more important role in the development of international production networks. In Fig. 3.1, the stacked bar charts show the proportion of machinery in the total exports and imports of manufactured goods in 2007, for East Asian, European, and American economies, respectively. The left stacked bars indicate the percentage of machinery in total exports, and the right stacked bars show the same for imports. The darker portions represent the percentage accounted for by parts and components, and the lighter portions represent finished products. The bars are in descending order of the percentage of parts and components in total exports, from left to right.

The proportion of machinery in total exports, and especially the proportion made up by machinery parts and components can be regarded as the extent to which an economy is involved in international production networks. On the other hand, the percentage for the import side does not differ greatly among economies. While Malta has the highest percentage of machinery parts and components in exports at more than 60 %, it is striking that Singapore and the Philippines achieve notably high percentages of parts and components in both exports and in imports. To be precise, parts and components represent 57 % and 54 % of Singapore's exports and imports of manufactured goods, respectively, and the corresponding percentages

[6] See Jones, Kierzkowski, and Chen (2005).

for the Philippines are 56 % and 64 %. This reflects brisk back-and-forth transactions of intermediate goods across borders, as a result of the fragmentation of production. As for Malaysia, Japan, the Republic of Korea, and Thailand, the percentage of all machinery industries also exceeds 50 %, and that of parts and components exceeds 30 % on both the export and import sides, indicating their deep participation in international production networks. The People's Republic of China, (henceforth PRC, here including Hong Kong, China) is also actively involved in such networks, as indicated by the fact that more than half of both exports and imports of manufactured goods are accounted for by machinery. Machinery parts and components account for only 20 % of exports, but more than 40 % of imports, which suggests an important role for the PRC as the factory of final assemblies for the world.

3.3 Structure and Mechanics

Research on the structure and mechanics of production networks consists of interactions between theoretical and conceptual thought and empirical studies. Without theory, we do not observe a fact. Without empirical studies, theory cannot be fertile. Fragmentation theory has played a central role in explaining the functioning of production networks. However, the elaboration and sophistication of production networks in East Asia has not been completely digested in formal theoretical modeling. Further collaboration between theory and empirical studies is clearly required.

This section discusses the fragmentation theory, vertical specialization, FDI and intra-industry trade, regional and global extension, fragmentation and agglomeration, and services offshoring.

3.3.1 Fragmentation Theory

Although international production and distribution networks in East Asia began to be formulated from the end of the 1980s, Jones and Kierzkowski (1990) made a head start in developing a theory of fragmentation. Their theory pointed out fundamental differences between trade in intermediate goods and trade in finished products, particularly in the flexibility of a firm's decision making in cutting out production blocks, and the existence of service link costs.

Figure 3.2 illustrates the original idea of fragmentation. Suppose that a firm originally produces a product in a large factory located in a developed country from upstream to downstream. The production processes in the factory, however, may have various characteristics; some could be capital- or human capital-intensive, while others could be purely labor-intensive. Some could be capital intensive but requiring constant human supervision. Hence, if the firm can separate some of the production processes and tasks according to type, design production blocks, and

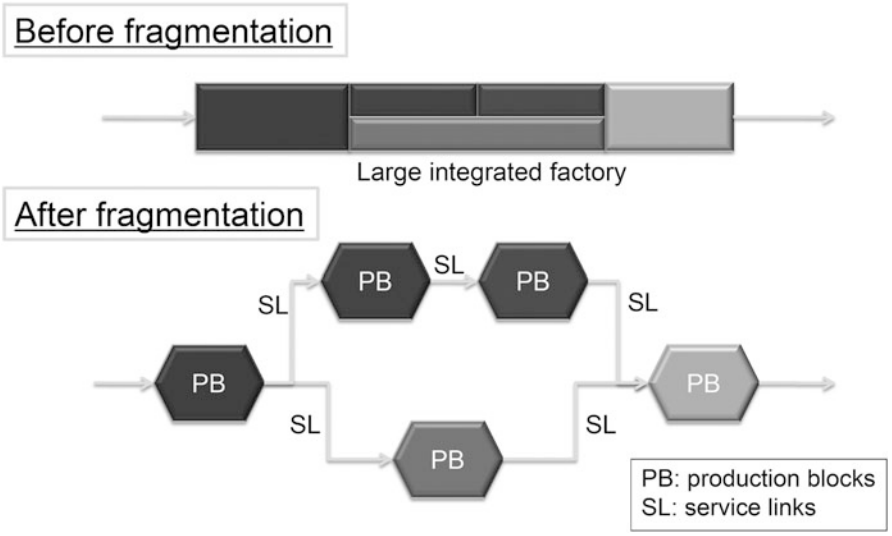

Fig. 3.2 The fragmentation theory: production blocks and service links (Source: Authors)

locate them elsewhere, total production costs may be reduced. This is the so-called fragmentation of production.

Fragmentation of production processes is economically viable if (i) the saving of production costs per se in production blocks is large and if (ii) service link costs incurred in connecting remotely located production blocks are small. Whether (i) is met depends on the technical separability of production processes, and the availability of different location advantages. Firms have a certain degree of freedom in how to cut out production blocks so as to exploit different location advantages in remote areas, while host countries may seek niche location advantages for each production block (ii) depends not only on trade barriers and transport costs, but also on various coordination costs, which make transactions in production networks relation-specific. In addition, service links often present economies of scale. These are the reasons why a simple disaggregation of industries in the framework of traditional trade theories cannot fully explain the division of labor at the level of production processes.

The flying-geese pattern developed by Prof. Akamatsu has long been referred to as a useful framework for understanding sequential catching-up in industrial development across East Asia.[7] However, we must be careful in applying the thesis to the current state of international division of labor in East Asia, since the thesis primarily deals with industrial division of labor, while what we observe is production-process division of labor. There are several novel elements in production fragmentation that did not exist when the theory was formed.

[7] See, in particular, Kojima (2000) for the flying-geese model.

For further development of the fragmentation theory, see a set of articles in Arndt and Kierzkowski (2001) and Deardorff (2001).

3.3.2 *Vertical Specialization, Vertical FDI, and Vertical Intra-industry Trade*

In order to quantify the extent of international fragmentation of production at the sectoral level, many of the existing empirical studies use input-output (I-O) tables. One I-O based measure of fragmentation focuses on the foreign content of domestic production, i.e. the share of (direct) imported inputs in production or in total inputs (see Feenstra and Hanson 1996). Another type of I-O measure, which was originally formulated by Hummels, Ishii, and Yi (2001), captures the (direct and indirect) import content of exports, which is specifically labeled as vertical specialization.[8] They showed that 21 % of the exports from ten Organisation for Economic Co-operation and Development (OECD) and four emerging economies were accounted for by vertical specialization activities, and that such activities had grown almost 30 %, accounting for 30 % of the growth in these countries' exports, between 1970 and 1990.[9,10] Yi (2003) incorporated the idea of vertical specialization into a two-country dynamic Ricardian trade model, so as to explain the magnified and nonlinear growth in the world manufacturing export share of GDP in the last few decades. The magnified increase in trade in response to global tariff reductions was explained by the so-called magnification effect. As a result of vertical specialization, tariff cuts lead to a magnified reduction in production costs because intermediate goods or unfinished goods can cross international borders multiple times. Goods that used to be produced entirely in one country become vertically specialized across countries, resulting in the extensive margin of trade growth.

However, in addition to the limited availability of data comparable across countries, I-O tables are not frequently updated. Therefore, some empirical studies on vertical specialization use bilateral trade data at the product level instead. Amador, Cabral, and Maria (2007) presented statistical evidence that vertical specialization activities are predominant in high-tech industries and geographically concentrated in

[8] In the literature, international fragmentation of production has been called alternative names such as vertical specialization, slicing the value chain, international production sharing, and outsourcing/offshoring.

[9] Following Hummels et al. (2001), vertical specialization is defined to occur when (i) goods are produced in multiple, sequential stages; (ii) two or more countries provide value added in the good's production sequence; and (iii) at least one country must use imported inputs in its stage of the production process, and some of the resulting output must be exported.

[10] Chen, Kondratowicz, and Yi (2005) updated the findings of Hummels et al. (2001) by using more recent I-O tables, showing also that trade in vertical specialized goods has increased over time.

East Asia, by calculating a cross-country product-specialization index for both exports and imports. In addition, while forerunner East Asian economies such as Japan; Hong Kong, China; the PRC; Singapore; Republic of Korea; and Taipei,China have ranked in the top 10 economies specializing in high-tech exports since the 1970s, Malaysia and the Philippines also have appeared in the top 10 since the early 1980s and the mid-1990s, respectively. They concluded that this catching-up pattern might reflect the reorganization of production processes in the region, through international fragmentation of production. Amador and Cabral (2009) also showed the evolution of vertical specialization activities in high-tech products in East Asia over the last two decades, using a measure of vertical specialization-based trade that combines information from I-O matrices and trade data.

Vertical specialization is closely related to the expansion of intra-industry trade. At a highly disaggregated level, intermediate goods and their relevant finished products in the same production chain tend to be classified in different product categories and regarded as inter-industry trade. At a more aggregate level, however, intermediate goods and the relevant finished products are more likely to be classified in the same category and regarded as vertical intra-industry trade. Indeed, the expansion of trade in East Asia has been accompanied by a drastic increase in the proportion of vertical intra-industry trade (Athukorala 2005; Wakasugi 2007). Also, there is evidence suggesting that the increase of vertical intra-industry trade in East Asia is accounted for by transactions between vertically specialized production processes rather than trade in quality-differentiated goods (Ando 2006).

As MNEs have become leading players in international trade, vertical specialization has developed in parallel with vertical FDI operations. The vertical FDI theory has recently evolved to allow for complicated cross-border production systems managed and operated by networking firms, i.e. so-called complex vertical FDI. Hayakawa and Matsuura (2011) demonstrate the validity of the concept of complex vertical FDI in the case of Japanese FDI in other East Asian countries. The empirical evidence they provided suggests the complicated nature of international production networks in East Asia, in the sense that Japanese MNEs have multiple affiliates in multiple countries, with different factor prices across the region.

Linking vertical intra-industry trade with multinational activities, Fukao, Ishido, and Ito (2003) reported that Japanese FDI has made a large contribution to the increase of vertical intra-industry trade in the electric machinery industry. Sohn and Zhang (2005), on the other hand, pointed out that Japanese FDI has a positive correlation with the share of horizontal intra-industry trade but a negative correlation with the vertical intra-industry share in trade between Japan and other East Asian countries. We need to examine this issue further, with a longer-term data set of international trade and FDI, to reach clarity in this debate.

3.3.3 Fragmentation and Agglomeration

Although cross-border production sharing exists between the US and Mexico, between the US and Costa Rica, and between Western and Eastern Europe, this

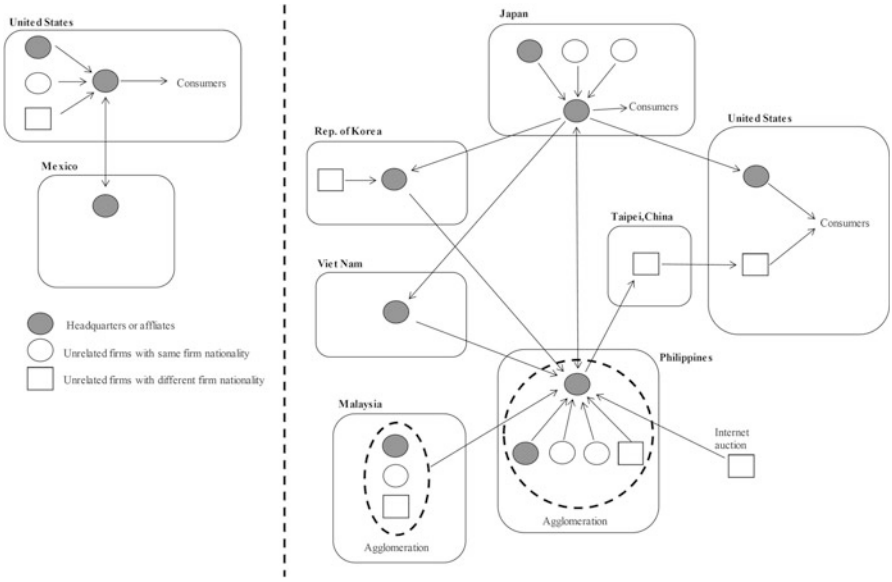

Fig. 3.3 Production networks: the US-Mexico nexus versus East Asia (Source: Ando and Kimura 2009)

production-process division of labor typically has a relatively simplistic structure, featuring back-and-forth, closed-loop, and intra-firm transactions. For example, a US firm might prepare a set of parts and components in the US, send them to its own factory in Mexico, and make the factory send finished products back to the US market (see the left-hand graphic in Fig. 3.3). In the case of East Asia, we observe open-ended "networks" of production-process division of labor, which cover a number of countries in a sophisticated web of intra-firm and arm's length (inter-firm) transactions (see the right-hand graphic in Fig. 3.3).

Ando and Kimura (2009) have presented statistical evidence from transactions by Japanese MNEs that finds long distance transactions, such as those between Japan and ASEAN countries, are predominantly intra-firm transactions. On the other hand, transactions within host countries by Japanese subsidiaries in developing East Asia are mostly arm's length. Middle-distance transactions, such as those among ASEAN countries, are half intra-firm and half arm's length. Furthermore, in some specific places in developing countries, industrial agglomerations begin to form in which vertical, arm's length, and just-in-time transactions among multinationals and local firms are activated simultaneously.

The concept of two-dimensional fragmentation proposed by Kimura and Ando (2005) breaks down and analyzes the outset of fragmentation in order to capture the sophistication of international production and distribution networks in East Asia. In addition to fragmentation in the dimension of geographical distance, the extended framework introduces fragmentation in the dimension of disintegration, in which a firm decides whether to keep some economic activities inside the firm or to outsource them to others (see Fig. 3.4). This framework works well to explain the

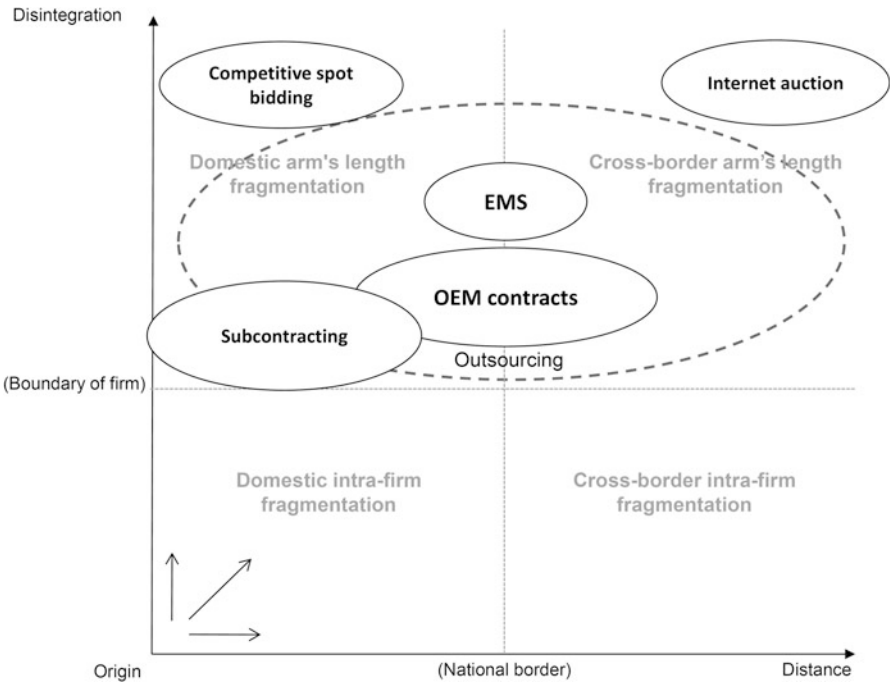

Fig. 3.4 Two-dimensional fragmentation: an illustration. *EMS* electronics manufacturing service, *internet auction* auction of customized parts and components through the internet, *OEM* original equipment manufacturing (Source: Kimura and Ando 2005)

sophisticated nature of fragmentation in East Asia, where both intra-firm and arm's length fragmentation of production processes develop. By introducing a close relationship between geographical proximity and arm's length transactions, the framework can also neatly describe the simultaneous development of firm-level fragmentation of production processes and industry-level agglomeration.

Developing East Asia is the only region where industrialization has reached the stage of forming industrial agglomerations in an open setting. These industrial agglomerations differ from what we have observed in other parts of the developing world. They are not simply agglomerations of population. They are different from import-substituting industrial agglomerations with trade protection. Rather, they have evolved from an unorganized group of production blocks to tight arm's length division of labor in an environment of extensive trade liberalization.

Machikita and Ueki (2010a, b) investigated the geographical extent of industrial agglomerations in ASEAN, using firm-level data from a questionnaire survey of manufacturing firms in Indonesia, the Philippines, Thailand, and Viet Nam. Machikita and Ueki (2010a) clarified the geographical distribution pattern of customers and suppliers, by presenting some facts which suggested firm-level capabilities and transaction costs associated with specific inter-firm relationships could influence the distances between customers and suppliers. Focusing on the

supplier side, Machikita and Ueki (2010b) further examined the implications of geographic proximity for the dynamic process of searching for a new supplier.

3.3.4 Services Offshoring

In East Asia, the development of production networks expands beyond the manufacturing sector to encompass services, even if the speed and frequency of transactions and the length of value chains may differ. Call centers, software outsourcing, and other types of services offshoring are well developed in India. Such operations are also observed to some extent in other parts of East Asia.

East Asian countries have sharply increased services offshoring since the early 1990s though the scope of material offshoring is still greater. As of 2000, 30 % of service inputs were accounted for by intraregional procurement, while the intraregional share was 50 % in the case of material inputs (Kang et al. 2010).

3.4 Conditions for Production Networks

The geographical extension of production networks is obviously skewed. Not all countries or regions can participate in production networks. A line of research digs into the factors and conditions that allow countries or regions to do so.

In the following, we review various efforts to identify conditions for production networks, from the viewpoint of regional comparison, skewed distribution of production networks at the country or provincial level, trade liberalization and free trade agreement (FTA) utilization, trade facilitation and infrastructure development, and exchange rate volatility.

3.4.1 Regional Comparison and Inter-regional Links

The degree of participation in production networks as well as the degree of sophistication of production networks differs widely across regions. In particular, the contrast between East Asia and other parts of the world is substantial. Hence, regional comparison of production networks can be an effective approach for identifying crucial factors in the development of production networks.

Kimura, Takahashi, and Hayakawa (2007) have found that geographical distance reduces trade in machinery parts and components much less in East Asia than in Europe. This empirical evidence implies that the service link costs associated with international fragmentation of production are substantially lower in East Asia than in Europe, contributing to large differences in the development of international production networks. As production networks have expanded across the region,

East Asian countries have deepened their economic dependence on one another, leading to de facto regional integration. Taking Latin America as a target for comparison, Aminian, Fung, and Ng (2009) concluded that East Asia is the more intensely integrated of the two regions, in terms of trade integration and in terms of the simultaneous improvement of export competitiveness in the manufacturing of parts and components. The latter point can be taken as an indication of the region-wide development of production networks.

Hayakawa, Ji, and Obashi (2011) explored the pattern of economic interdependence among East Asian countries in the case of electric machinery industry, in which production networks have developed dramatically in East Asia and other regions.[11] In East Asia, unlike in Europe, the scale of industry in one country is positively correlated with its scale in neighboring countries. This empirical evidence of positive spatial interdependence suggests that East Asian countries achieve simultaneous production expansion as a result of the cross-border compartmentalization of production processes of the industry by participating in regional production networks.

Differences in location advantages across countries are thought to enhance international fragmentation of production. In the case of intraregional trade in machinery parts and components in East Asia, a positive association has been detected between trade flows and income gaps as a proxy for differences in location advantages (Kimura et al. 2007). By contrast, in the case of Europe, this association is estimated as negative, which suggests that trade in horizontally differentiated products is dominant.

From the perspective of Japanese multinational activities, Kimura and Ando (2003) presented evidence suggesting that Japanese firms have played an important role in developing international production networks in East Asia, while they have not yet either constructed a critical mass of industrial clusters or formulated efficient vertical production chains in Latin America. Ando, Arndt, and Kimura (2009) focused on strategic behavior of Japanese and US firms and argued that firms of both nationalities actively extend production networks in East Asia, and do not in Latin America. Matsuura, Tanaka, and Urata (2010) further investigated different patterns of foreign affiliate sales and exports between Japanese and US MNEs and provided empirical evidence that comparative advantage motives are dominant for the location choice of Japanese MNEs, unlike in the case of their US counterparts. Given that a firm's decision regarding whether or not to fragment and offshore a part of production process is sensitive to the level of trade costs, this result can be interpreted as suggesting that the geographic proximity of East Asian countries with different location advantages creates a favorable environment for Japanese firms to manage production chains efficiently across borders.

A couple of recent studies shed light on the role of inter-regional links in the geographical extension of production networks from regional to global. Ando and

[11] East Asia's economic interdependence is further discussed in terms of the "decoupling East Asia" debate in Sect. 3.5.3.

Kimura (2013b) traced the development of international production networks in Europe by employing the commodity-level international trade data, from the perspective of a stronger link between Central and Eastern Europe (CEE) and East Asia, particularly in the electric machinery sector. Ando and Kimura (2014) found a similar link between North America, particularly Mexico, and East Asia.

3.4.2 Skewed Distribution of Production Networks

East Asian production networks are now the most advanced and sophisticated in the world. However, we must note that not all of its countries and regions have been included in these. Actually, only a small portion of East Asia participates in quick and high-frequency production networks in machinery industries, while significant thresholds determine whether countries or regions can join them.

Figure 3.5 is another version of Fig. 3.1, extracting just the economies of East Asia. Machinery trade as a proportion of total manufacturing trade, particularly on the export side, is widely different among countries. In Singapore, the Philippines, Malaysia, Japan, and the Republic of Korea, over 70 % of manufacturing exports is made up by machinery. Thailand and the PRC including Hong Kong, China, both score above 50 %, and the proportion of machinery parts and components in exports

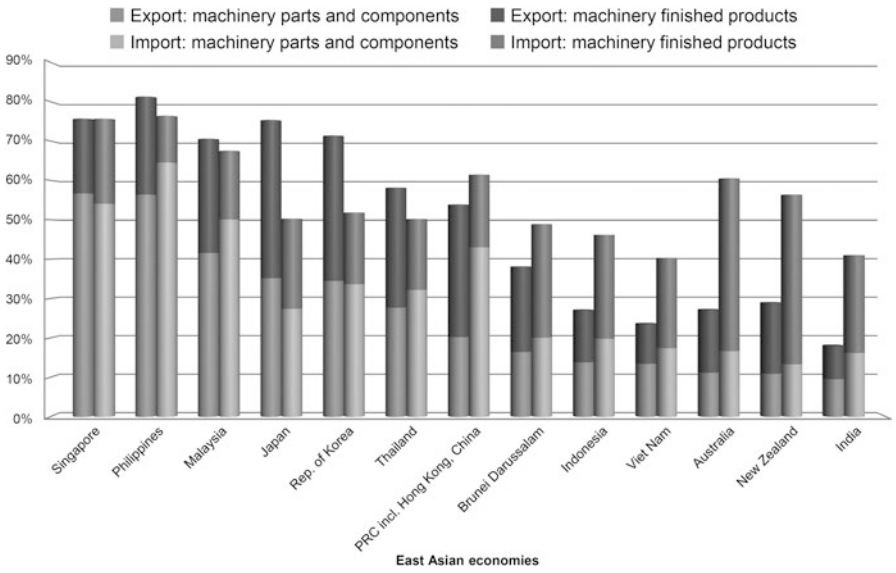

Fig. 3.5 Machinery as a share of total exports and imports of manufactured goods, 2007: East Asia only. The *bars* are in descending order of the percentage of machinery parts and components in total exports of manufactured goods, from *left* to *right*. Note: All figures are calculated using export and import statistics for bilateral trade in manufactured goods (Source: Kimura and Obashi 2010)

is also considerably high in these economies. However, other East Asian countries, especially Indonesia, Viet Nam, and India, have low export ratios of machinery, which indicate that their participation in international production networks has not yet extended to full scale.

Kumagai et al. (2010) studied the location of manufacturing sub-sectors (automotive, electric and electronics, textile, food production, etc.) in ASEAN and a part of other East Asian countries. At each provincial level, the authors first checked whether manufacturing value-added occupied 10 % or more of GDP. Where the manufacturing share was 10 % or more, they then identified the largest sub-sector among the automotive, electric and electronic, textile and garment, food processing, and other manufacturing industries. The figures show that only a small number of provinces participate in quick and high-frequency production networks, in automotives and electronic goods. Outside of such areas, some provinces host textiles and garment production, and food processing, which are sometimes connected with the regional and world market but whose production networks are typically slow and low-frequency. Further out of these provinces, little manufacturing activities are found at all.

One of the important properties of international production networks is the existence of a substantial threshold in participation. In order to join production networks, countries or regions must meet a certain set of criteria. The reasons for the existence of these qualification criteria are threefold.

First, when MNEs design the geographical structure of production networks, both location advantages for production blocks and service link costs are thoroughly assessed. Not all countries or regions can pass this strict test. Second, location advantages for production blocks and service links between production blocks are accompanied by dynamic economies of scale at an industry or macro level. Once a country or a region enters into production networks, and the number of firms participating in such networks increases, information and know-how among both firms and host countries starts to accumulate, further reinforcing the existing location advantages and service links. Third, there exist substantial costs for a firm in establishing relation-specific transaction channels and constructing production networks.

The latter two factors will act as a form of sunk cost which generates the path-dependent nature of network participation. These can also be interpreted as the other side of the coin of the durability and resilience of production networks discussed later in Sect. 3.5.2.

In the realm of policy research, the Economic Research Institute for ASEAN and East Asia (ERIA) proposed the Comprehensive Asia Development Plan (CADP) to the 2010 East Asia Summit, in which the mechanism of fragmentation can be used to assist progressive planning of logistics and other economic infrastructure (ERIA 2010). Another ERIA study investigated small and medium-sized enterprises (SMEs)' participation in production networks, and discussed how to enhance that participation in future (Thanh et al. 2010).

3.4.3 Trade Liberalization and FTA Utilization

One of the important factors which affect service link costs is trade liberalization. East Asia was a forerunner in developing international production networks because of its novel policy regime toward trade.

Aggressive attraction of FDI by developing East Asian countries started in the latter half of the 1980s. International competition in attracting FDI became harsh in the early 1990s, and unilateral "race-to-the-bottom" trade liberalization occurred in the region, particularly in electronic parts and components under the umbrella of the Information Technology Agreement (ITA) (Baldwin 2006).

Unilateral trade liberalization, however, was not successful in cleaning up trade barriers in import-substitution-type industries, including automobiles, electric appliances, iron and steel, and petro-chemicals. Network-forming industries prefer free trade, while import-substituting industries would like to keep trade protection. Although such inconsistency was partially mitigated by a duty drawback system and other measures, a consistent trade regime was still lacking. After the Asian currency crisis in 1997–98, Asian regionalism was accelerated, in ASEAN (under the ASEAN Free Trade Area, or AFTA) and beyond (under the ASEAN + 1 FTAs), and as a result, the trade regime seemed to become much more consistent than before.

It is open to question whether FTAs truly usher in freer trade or not. Hiratsuka, Sato, and Isono (2009) investigated how East Asian FTAs have affected the behavior of Japanese firms, including their affiliates operating overseas. They claimed that ongoing FTAs are neither well known nor well utilized by Japanese firms. However, a Japan External Trade Organization (JETRO) Survey for Japanese multinationals indicated that the under-utilization of FTAs is mostly due to small gaps between preferential and MFN tariffs, the utilization of a duty-drawback system, and related factors, rather than due to the complexity or obscurity of FTAs themselves (JETRO 2008, 2009). Using micro data from the same JETRO Survey, Hayakawa et al. (2013a) analyzed the pattern of FTA utilization by Japanese affiliates operating in Asia and confirmed such patterns. They found that the smaller the affiliate is, or the less diversified the origins of its procurements, the less likely it is to utilize an FTA scheme in exporting abroad. After a comprehensive survey of firms not only in Japan but also in Singapore, the Republic of Korea, Thailand, and the Philippines, Kawai and Wignaraja (2009) concluded that the complication created by overlapping FTAs is not very serious, even if more facilitation is certainly desirable.

3.4.4 Trade Facilitation and Infrastructure Development

In the Asia-Pacific Economic Cooperation (APEC) and ASEAN countries, tariff reductions have played an important role in reducing overall trade costs, yet

progress on non-tariff trade costs has been much more limited (Shepherd 2010). This suggests that APEC and ASEAN should refocus their trade facilitation efforts to concentrate on those. The development and expansion of international production networks in East Asia may create pressures for trade facilitation because fragmentation of the production process is only profitable if the cost of transporting parts and components across borders is low enough in time and money.

With this in mind, Pomfret and Sourdin (2009) examined whether ASEAN countries have actually reduced the costs of trade with a third-country market, Australia, and found that ASEAN countries reduced trade costs by less than the global average in the early 1990s, but by more than the average from the mid-1990s to 2003. They concluded in their paper that both the proliferation of trade agreements and falling trade costs in ASEAN may be affected by the emergence of regional supply chains, which put pressure on governments to reduce trade costs. Hayakawa (2007) applied the empirical method of measuring border effects developed by Head and Mayer (2000) and quantified border barriers in intermediate goods transactions in East Asia by employing international input-output tables in 1985, 1990, and 1995. He found that barriers in East Asian countries steadily declined over time.

Brooks and Stone (2010) have also argued that countries participating in production networks have a strong incentive to cooperate with each other, particularly on reducing the costs of trading between themselves. Their empirical analysis, based on a computable general equilibrium framework, indicates that even a relatively modest reduction in trade costs can yield significant gains in APEC member countries; gross domestic product in the region expands, and countries move into a more diversified trading pattern. More interestingly, the expansion of exports due to trade facilitation is predicted to be dominant in intra-APEC trade, compared to extra-regional trade.

The extent of government regulations faced by logistics service providers varies among ASEAN + 6 countries (Hollweg and Wong 2009). Singapore and Australia, followed by Japan and New Zealand, are relatively open to trade in logistics services, whereas Malaysia, the PRC, Indonesia, the Lao PDR, the Philippines, and Viet Nam are relatively restrictive. Indeed, according to a semi-structured questionnaire survey taken among private companies and chambers of commerce in Cambodia, the Lao PDR, Myanmar, and Viet Nam, logistics infrastructure, particularly soft logistics infrastructure, appears to be a constraint on these countries' participation in production networks (Banomyong and Ishida 2010).

Shepherd and Wilson (2009) presented empirical evidence that trade flows in ASEAN are particularly sensitive to transport infrastructure and ICT networks. Their estimates suggested that the region could make significant economic gains from trade facilitation reform, which would be considerably larger than those from comparable tariff reforms. This suggests that transport infrastructure can play in enhancing intraregional trade in ASEAN.

Kumagai et al. (2008) introduced the Institute of Developing Economies (IDE) Geographical Simulation Model and examined the impact of the East-West Economic Corridor on continental South East Asia at sub-national level. Their

simulation results indicated that border costs play a big role, often a more important role than that of physical infrastructure itself, in the location choice of populations and industries.

3.4.5 Exchange Rate Volatility

The exchange rate of local currencies is no doubt a crucial aspect of location advantages in producing any sort of tradable good. Some countries may have strong currencies due to an abundance of natural resources or import-substitution exchange rate policies, and are subject to a sort of Dutch disease, which may make it difficult for them to participate in production networks.

In addition, the volatility of exchange rates is one of the crucial uncertainties for business partners' competitiveness, along with service link costs. As a consequence, firms or production plants located in countries with high volatility in exchange rates are less likely to be incorporated into production networks. Indeed, some Japanese firms have reported that exchange rate stability is essential for back-and-forth transactions of intermediate goods (Ito et al. 2008).

Some empirical studies have investigated how exchange rate volatility affects parts and components trade within international production networks in East Asia. Thorbecke (2008) presented evidence that exchange rate volatility decreases exports of electronic parts and components among East Asian countries. Hayakawa and Kimura (2009) provided further evidence that the negative impact of exchange rate volatility on trade in machinery parts and components is severe compared to the case of finished products. In addition, empirical findings from Kiyota, Matsuura, and Urata (2008) have indicated that host currency/yen exchange rate volatility discourages Japanese MNEs from establishing a foreign affiliate in a country. This suggests that limiting bilateral exchange rate fluctuation is one of the most important prerequisites for a country to participate in production networks.

3.5 Properties and Implications

Production networks have revealed a number of novel properties beyond our original expectations. Their consequences expand to touch on the whole discussion on globalization and regionalism. This section provides a literature survey on gains from fragmentation, durability and resilience, decoupling, the role of the PRC, technology transfer and spillover, and impacts on economies of MNEs' home countries.

3.5.1 Gains from Fragmentation

One important property of geographic fragmentation is that a firm can decide how best to cut out production processes and design production blocks. Considering the most effective utilization of location advantages with its own firm-specific assets such as production technology, managerial ability, and inter-firm relationships, a firm will design and organize production networks with a certain degree of freedom. This provides ample flexibility for a firm to adjust for niche location advantages.

From the other side of coin, developing countries may try to develop particular niche location advantages, in order to attract production blocks, rather than attempt the more difficult job of countrywide fundamental improvement of the investment climate. With fragmentation, it would be much easier for less developed countries (LDCs) to start industrialization than in the past by attracting some pieces of production blocks.

The benefits of production fragmentation at the firm level, particularly benefits deriving from different location advantages, have barely been measured empirically. Hayakawa, Kimura, and Matsuura (2009) presented the first attempt, to the authors' knowledge, at empirically capturing the benefits of fragmentation. Using Japanese firm-level data, they found that the larger the gap in the capital-labor ratios between fragmenting firms' home and overseas activities, the more their cost efficiency improves.

Kang et al. (2010) demonstrated the positive impact of increased offshoring on total factor productivity and showed that such productivity effects are more significant in services offshoring than material offshoring.

3.5.2 Durability, Footloose FDI, and the Response to the Global Financial Crisis

FDI is sometimes criticized as footloose; MNEs do not deeply commit to local production, and slight changes in competitive conditions may easily cause local production plants to move elsewhere. In the case of FDI in the context of production networks, production blocks tend to carry thin slices of value added, and such FDI may be expected to present an even stronger footloose character.

However, a series of empirical studies, as well as the extended fragmentation theory, have claimed quite the opposite. Transactions in production networks, particularly international trade in machinery parts and components, are much more stable than other types of transactions. This is due to the relation-specific nature of transactions in a production network compared with transactions on the spot market with open-bidding. To set up or restructure production networks, a firm has to pay a substantial sunk cost in identifying location advantages and the strength of business partners, as well as building up reliable links. Hence, once production networks are constructed, transactions become relation-specific and stable.

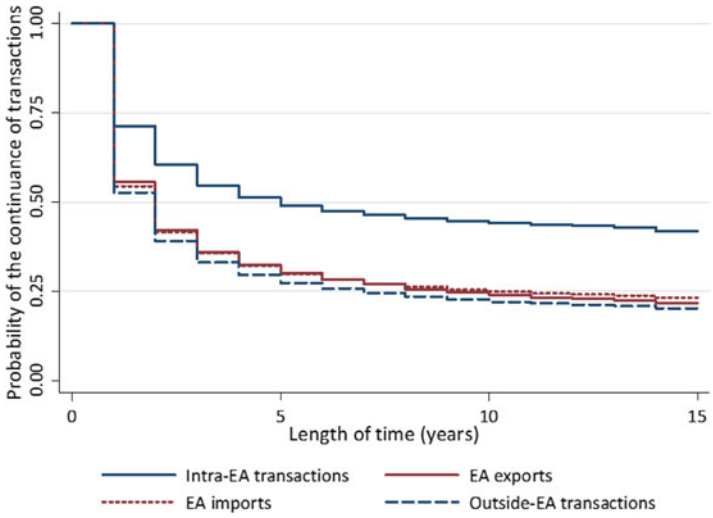

Fig. 3.6 Stability of East Asian production networks. *EA* East Asia (Source: Obashi 2010b)

At the detailed level of trade commodity classification, bilateral trade is quite often interrupted year by year. Obashi (2010a) applied survival analysis techniques to intraregional trade in East Asia and proved that trade in machinery parts and components is longer-lived and more stable than trade in finished products. Trade relationships in machinery parts and components are more likely to be maintained between countries even at a long distance, regardless of exchange rate fluctuations. The probability of discontinuing trade relationships of finished machinery products, however, is more likely to be sensitive to trade costs, as well as to exchange rate fluctuations.

Figure 3.6 presents further results (Obashi 2010b). Even within bilateral trade in machinery parts and components, transactions within East Asia are longer-lived and more stable than transactions with outsiders. East Asian countries are more likely to engage in long-lived trade relationships of machinery parts and components with each other than with outsiders, unlike in the case of finished products. Moreover, Obashi (2011) conducted a detailed analysis on the period of the Asian currency crisis and found a resilience in production networks even against negative macro shocks.

Ando and Iriyama (2009) conducted a micro-data analysis on exports and imports by Japanese manufacturing firms between 1994 and 2004, and found that machinery firms, with greater foreign operations under their control, were better than others at absorbing shocks from exchange rate fluctuations by adjusting intra-firm transactions. Relation-specific transactions in production networks can thus work as shock absorbers. As related evidence, Kiyota, Matsuura, and Urata (2008) empirically showed that high exchange rate volatility causes a shift from inter-firm to intra-firm transactions, using affiliate-level data for Japanese MNEs.

Naturally, however, less economically important trade relationships might be broken off in the process of restructuring production networks to be more efficient or sophisticated. Indeed, during the period 1995–2003, the annual average divestment rate of Japanese electronics manufacturing affiliates stood at 14–19 % in newly industrializing economies (NIEs) of Hong Kong, China; Singapore; the Republic of Korea; and Taipei,China: though the corresponding rates for Indonesia, Malaysia, the Philippines, and Thailand (ASEAN4) and the PRC are much lower at 3–9 %. Moreover, one third of the divestment cases in NIEs are accompanied by relocations to lower wage countries, particularly to the PRC (Belderbos and Zou 2006). This fact indicates that divestments and relocations were related to Japanese firms' strategies for adapting to the changing competitiveness and investment climate in the host country and abroad. Nevertheless, Belderbos and Zou (2006) reported that most relocation cases from ASEAN countries to the PRC have not entailed full factory closures, but relocations of the manufacturing of specific low-end products. Even if production and market conditions become less favorable for specific operations, multinational firms seem to be reluctant to completely withdraw from the host country once they have entered it.

Much attention has been paid to the sharp fall in trade all over the world amid the global financial crisis. Particularly in East Asia, the export-oriented manufacturing industries and countries dependent on them were hit the hardest (ADB 2009a, b). The global economic downturn has resulted in even larger fall in international trade: world trade shrank by 8.9 %, while world GDP declined by 1.3 %. Besides the credit crunch, it has been argued that international production networks provided a real transmission mechanism that may help explain the widespread decrease in trade (Bénassy-Quéré et al. 2009; Escaith 2009; Escaith et al. 2010; Yi 2009). More importantly, this argument can be interpreted as suggesting that there is a flip side to the shock transmission mechanism of international production networks. When there is a sustained recovery in global demand, international production networks should be a force leading to a synchronized surge in global trade (Yi 2009). In fact, Ando (2010), Ando and Kimura (2012a), and Okubo, Kimura, and Teshima (2014) have shown a quick and strong recovery of international production networks in East Asia.

3.5.3 Decoupling or Dependence on G3 Demand?

Petri (2006) showed that East Asian countries have not only increased intraregional exports and imports, but compared to randomly predicted trade, they have become more biased toward intraregional trade partners since the mid-1980s, though the intraregional economic interdependence had declined over most of the post-World War II period. International production networks stretched across the region have certainly played a pivotal role in enhancing economic interdependence among East Asian countries. Many existing empirical studies have shown that the expansion of intra-industry trade, in particular that driven by vertical specialization, leads to

synchronized business cycles (Calderón et al. 2007; Imbs 2004). In terms of East Asia, Shin and Wang (2004) found that intra-industry trade is a major factor generating higher co-movements of output among countries. Given the rapidly growing regional economy and the strengthened intraregional economic ties, such evidence provoked the notion of "decoupling" or "uncoupling," in that the East Asian region has become a self-contained economic entity with the potential to maintain its own growth dynamism independent from the global business cycle.

In the heated debate over "decoupling East Asia," Athukorala (2005) and Athukorala and Yamashita (2006) have pointed out that the rising intraregional trade in parts and components has become more reliant on final demand from consumers outside East Asia, raising questions about the validity of the "decoupling East Asia" view. They contended that deepening regional integration appears actually to have reinforced East Asia's linkage with the global economy. Focusing on developing East Asian countries, ADB (2007) demonstrated that the region's increasing trade openness and integration, within itself and with the G3 (the United States, the European Union (EU), and Japan), has led to a higher degree of extra-regional and intraregional business cycle synchronization. Kim, Lee, and Park (2011) presented further evidence suggesting that the economic interdependence between developing East Asian countries and advanced countries such as the G3 has become bidirectional rather than unidirectional. Moreover, the export experience in the face of the global financial crisis has been seen as evidence supporting the view that developing East Asia remains vulnerable to cyclical downturns in the G3 (Athukorala and Kohpaiboon 2009).

On the other hand, Y.C. Park and Shin (2009) argued that the region's business cycle has become more idiosyncratic partly because East Asia has diversified its export markets to other parts of the world, so that its dependence on the US market has declined. Ando (2010) and Kimura and Obashi (2010) have argued that even in the case of finished machinery products, the growth of the East Asian market itself is substantial and the extra-regional markets are diversified rather than concentrating on the US or EU.

3.5.4 PRC: Threat or Opportunity?

The rise of PRC has triggered fears of increased competition for developing countries and hollowing out of manufacturing firms in advanced countries. In particular, East Asian neighbor countries are likely to be exposed to such a threat given their geographical proximity. Alongside the surge of its exports, however, the PRC also has a growing appetite for imports, and offers opportunities, too, for its neighbors.

The impact of the PRC's emergence on other East Asian countries' export performance has been investigated extensively (Athukorala 2009; Eichengreen et al. 2007; Greenaway et al. 2008; Lall and Albaladejo 2004). These existing studies adopt different approaches, but reach some coherent conclusions, to the

effect that East Asian countries face different kinds and intensity of competitive threat from the PRC, depending on their particular development stage and location advantages.[12] Regarding the export displacement effects due to the expansion of the PRC's exports, less-developed East Asian countries' exports of consumer goods and high-income countries' exports of low-technology or labor-intensive manufactured goods seem to be crowded out in third markets. As for the offsetting effects due to the PRC's economic growth, the PRC seems to increase imports of capital goods from more advanced East Asian countries.

In the light of the PRC's role in regional production networks, Athukorala (2009) argued that the PRC's integration into the networks as a major assembly center has opened up new opportunities for other East Asian countries to specialize in parts and components production.[13] Despite of the emergence of the PRC, countries could specialize in specific activities in the production chain according to technological complexities and intrinsic country-specific cost advantages.

3.5.5 Technology Spillover, Technology Transfer, and Export Creation

Once a certain density of vertical links among multinationals is developed in industrial agglomeration, local SMEs begin to have a chance to enter production networks. Local SMEs often have advantages in price competitiveness vis-à-vis multinational SMEs. Once they are successful in obtaining a certain level of non-price competitiveness, they are qualified to participate in vertical division of labor in industrial agglomerations. There exists a huge empirical literature on agglomeration and technology spillover using firm-level micro data. However, most of the studies have not pinpointed the nature of innovative information, and the direction in which it flows.

Machikita and Ueki (2011a, b) have investigated the role of production networks in industry upgrading. Using original survey data from manufacturing firms in Indonesia, Thailand, the Philippines, and Viet Nam, Machikita and Ueki (2011a) provided empirical evidence that linkages with local and foreign firms play a role in reducing the search cost of finding new suppliers and customers.[14] Their companion

[12] The outcome would also depend on the organization of firms. Lall and Albaladejo (2004) claim that independent local firms are likely to compete more directly with the PRC than foreign affiliates of multinationals incorporated into global supply chains, which could allow the firms to adjust more gradually to the changing technological and other capabilities in the PRC.

[13] In this regard, however, the share of finished products in the PRC's imports from developing East Asian countries have increased since the mid-1990s, in contrast to the decreased share of parts and components (D. Park and Shin 2009).

[14] Innovations are classified into the three broad categories in Machikita and Ueki (2011a, b): (i) product innovation; (ii) process innovations, including adoption of new technology and organizational changes to improve product quality and cost efficiency; and (iii) securing new customers and new suppliers efficiently.

paper further suggested that face-to-face communication and just-in-time relationships have different effects on product and process innovation.[15]

From the perspective of export spillover, Swenson (2008) detected a positive relationship between multinational firm proximity and the formation of new export connections by local firms in the PRC. As the positive association due to own-industry multinational presence is particularly strong, she concludes that information spillovers may enhance the export capabilities of local domestic firms. Some empirical studies have more explicitly dealt with the impact of the multinational presence on the local firm's decision to export. For example, by utilizing census data for Indonesian manufacturing firms, Narjoko (2009) presented evidence suggesting that the multinational presence raises the likelihood of export market participation of local firms, through technology and information channels.

3.5.6 Impacts on Parent Country Economies

From the viewpoint of investor developed countries, the impact of outsourcing or offshoring on their domestic economies is often a profound concern. The journalistic as well as intellectual literature in the US and Europe often claims that the offshoring of corporate activities to less developed countries reduces operations and employment at home.[16] However, the effect of FDI on domestic operations is not necessarily negative; it depends on the extent to which cost reduction through FDI allows a firm to strengthen its competitiveness, and whether the firm maintains activities at home that are complementary to operations abroad. The effect of FDI on employment and economic activities at home is inherently an empirical issue.

Ando and Kimura (2012b, 2013a) compared firms expanding operations in East Asia with those not expanding operations between 1998 and 2006 and found that Japanese manufacturing firms expanding operations in the region, particularly in the machinery sector, are more likely to keep or increase domestic employment. In addition, machinery firms expanding operations in the region do not necessarily reduce the number of domestic establishments or affiliates, and manufacturing firms with expanding operations, particularly in machinery sectors, tend to intensify import-export activities with the region. At least at the individual firm level, the fragmentation of production by Japanese manufacturing firms, particularly in machinery sectors, seems to generate additional jobs and operations at home. Hijzen, Inui, and Todo (2007) applied more rigorous econometric methods, and confirmed these results. Their empirical analysis, based on the propensity score matching method, indicated that Japanese firms expanded both employment and

[15] A 3-year study on agglomeration and innovation by ERIA investigates innovative information flows among firms, with and without foreign capital, in ASEAN. See Limskul (2009) and Intarakumnerd (2010). Machikita and Ueki (2010a, b, 2011a, b) are works based on this project.

[16] See for example Samuelson (2004) and Blinder (2006).

output at home after establishing a foreign affiliate. In this line of research, Hayakawa et al. (2013b) focused on Japanese manufacturing firms and explicitly distinguished between horizontal and vertical FDI. In the case of vertical FDI, defined as establishing an affiliate in a developing country, their findings suggested that investing firms increased the demand for skilled labor in the production sector at home, as a result of production specialization in skilled-labor-intensive activities.

Changes in skill composition in domestic operations due to globalizing corporate activities have been another focus of interest. Ito and Fukao (2005) used the share of vertical intra-industry trade at the industry level as a broad outsourcing measure and found that vertical intra-industry trade, particularly vertical intra-industry trade with Asia, raises the skill intensity (calculated as the share of those working in professional and technical or managerial and administrative fields) in the period between 1988 and 2000. Head and Ries (2002) investigated the influence of offshore production by Japanese multinationals on domestic skill intensity at the firm level, and found that additional foreign affiliate employment in low-income countries raised skill intensity, expressed as the non-production share of the wage bill at home. A skill shift in domestic operations is an indirect piece of evidence of the fragmentation of production, as well as an indication of possible aggravation of income disparity between skilled and unskilled labor.

3.6 The Way Ahead

Although our "subjective" survey is by no means exhaustive, we hope to have successfully provided an impression of the depth and quality of the literature related to production networks in East Asia. Categorizing the literatures into (i) structure and mechanics of production networks, (ii) conditions for production networks, and (iii) properties and implications thereof seems to work well for reviewing and categorizing the vast pool of related studies.

Studies on production networks face a number of fundamental difficulties. The theory of production networks is incomplete, and it does not scale up to industry- or macro-level in a convincing way. Moreover, production networks are not fully observed in official figures such as international trade statistics. Because firm heterogeneity as well as the heterogeneity of inter-firm relationships is at the center of mechanism, micro panel data analysis is certainly useful. However, such data rarely tell us much about market structure, competition, and inter-firm relationships. We researchers are just beginning to form a broad consensus on the nature and characteristics of production networks.

There is clearly a great deal of room for further research. In particular, the following three lines of research stand out. First, theory and its direct empirical underpinning should be attempted in a more rigorous manner. Second, although this chapter mainly reviews the positive analysis of the mechanics and properties of production networks, we should further conduct normative analysis related to production networks: especially in light of their potentially transformative effects.

Policy discussion related to production networks has profound importance. Third, collaboration with other disciplines, either within or outside of economics, should be effective in understanding this important feature of the East Asian and global economy.

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