North American Journal of Economics and Finance 24 (2013) 125–138

Contents lists available at SciVerse ScienceDirect

North American Journal of Economics and Finance

Intra-industry trade, fragmentation and export margins: An empirical examination of sub-regional international trade

Yushi Yoshida*

Faculty of Economics, Shiga University, 1-1-1 Banba, Hikone 522-8522, Japan

ARTICLE INFO

Article history:
Received 7 December 2011
Received in revised form 14 July 2012
Accepted 16 July 2012

Keywords:
Export variety
Fragmentation
Intra-industry trade
Regional trade
Vertical specialization

ABSTRACT

This study contributes to the existing empirical investigation of international trade by providing new evidence of intra-industry trade using sub-regions within a nation. We calculate the Grubel–Lloyd intra-industry trade index for 41 Japanese regions with Korea during the period from 1988 to 2006. In sub-regional intra-industry trade regression models, we introduce extensive and intensive margins of prefecture exports as new explanatory variables. We find that a rise in sub-regional intra-industry trade is driven by the introduction of a new variety of exports, while intra-industry trade is discouraged by an increase in the trade value of products that are already exported.

1. Introduction

The growing importance of intra-industry trade over the last two decades is well recognized. For example, the rapid growth in East Asian intra-regional trade can be attributed in large part to recent developments in intra-industry trade (Kimura, Takahashi, & Hayakawa, 2007; Murshed, 2001). Murshed (2001) documents that the share of intra-industry trade as a proportion of total manufactured trade in Asian economies has increased since 1980. Kimura et al. (2007) observed a 1000% growth in machinery parts and components trade in East Asia from 1987 to 2003.

Kimura et al. (2007) further claim that component trade in East Asia is driven by international fragmentation of the production process, as explained in Arndt and Kierzkowski (2001). Firms fragment the production process, choosing different countries for each stage of production. As a result, a capital-abundant country may import parts and components produced in labor-abundant countries and export finished products back to these labor-abundant countries.

* Tel.: +81 749 27 1089.
E-mail address: yushi.yoshida@biwako.shiga-u.ac.jp

1062-9408/$ – see front matter
http://dx.doi.org/10.1016/j.najef.2012.07.003

Intra-industry trade due to the international fragmentation of production must be vertical in nature whereas intra-industry due to consumers' preferences for larger variety is horizontal (Krugman, 1979; Lancaster, 1980). Hummels, Ishii, and Yi (2001) uses input–output tables to examine a phenomenon that is closely related to vertical intra-industry trade, vertical specialization, or the use of imported inputs to produce goods that are then exported. When vertical specialization extends to more than two countries, the value-added through the global chain of production also becomes important (Koopman, Powers, Wang, & Wei, 2011).

One way to measure vertical intra-industry trade is to use the threshold value of relative unit values of exports and imports (Greenaway, Hine, & Milner, 1994). However, vertical intra-industry trade can occur for reasons other than the fragmentation of production. Consumers benefit from having the option to choose from different sets of qualities (Flam & Helpman, 1987). A high-income country exports high quality products while importing low quality products of the same type. Therefore, we cannot be sure whether vertical intra-industry trade is caused by consumers' tastes for different qualities or by the fragmentation of production.

A more direct way to capture the degree of fragmentation occurring is to use firm-level datasets. At the firm level, we can identify two flows of trade as part of the fragmentation of production: a trade flow out of a firm that is later matched by an incoming trade flow of the same product group and vice versa. Rather than relying on firm-level observations, we suggest a methodology that restricts trade flows to a much smaller region than a country. Intra-industry trade measured using this methodology can reflect a higher proportion of trade caused by fragmentation in observed intra-industry trade.[1]

One of the most important contributions of this paper is to provide new evidence for the international fragmentation of production and for vertical specialization in Asia. We do so by introducing sub-regional intra-industry indices as a proxy for these direct measurements.[2] Many previous studies highlight the important role of fragmentation and vertical specialization in explaining international trade in Asia. For example, by examining vertical intra-industry trade in East Asia, Ando (2006) finds that the fragmentation of international production is a major cause of the observed high degree of vertical intra-industry trade. Athukorala and Yamashita (2006) document that vertical specialization in Asia actually caused Asian economies to depend more on extra-regional trade in final goods. Moreover, by comparing proposed measures of vertical specialization across the world, Amador and Cabral (2009) find that East Asia shows the most significant and growing vertical specialization activities. This study intends to shed some new light on fragmentation of production and vertical specialization in Asia by examining traditional intra-industry trade at much smaller sub-regional levels within a country.

Our analysis depends heavily on Japanese international trade data provided by the Japan Custom, Ministry of Finance (JCMF). The JCMF dataset classifies traded products using 9-digit classifications and includes over 7000 codes in export and over 8000 codes in imports. The first six digits correspond to the international standard classification of the Harmonized System (HS). In addition to international trade at the country level, the JCMF also provides detailed international trade data at the level of international ports in Japan. We aggregated data from these international ports to construct an international trade dataset for prefectures. Because some prefectures have no international ports or reported no positive international trade, we have data for 41 out of 47 existing prefectures.[3] It should be noted that prefectures are only political units, and an economic unit may extend over two adjacent prefectures. However, prefectures are large enough to encompass most industry clusters within a geographic area. The sample covers the period from 1988 to 2006.

---

[1] This sub-regional methodology also has an advantage over firm-level observations. The sub-regional approach can capture intra-industry trade at the level of industry clusters in cities, while the firm-level approach may miss, for example, a trade flow passing through another subsidiary before reaching the final parent firm.

[2] It should be noted that vertical specialization need not take the form of using imported inputs from the *same* industry as the one for the final exports. Thus, the implications of vertical specialization have a narrower scope when one uses sub-regional intra-industry trade indices, as we do in this paper. We thank an anonymous referee for pointing this out.

[3] These 41 prefectures are Aichi, Akita, Aomori, Chiba, Ehime, Fukui, Fukuoka, Fukushima, Hiroshima, Hokkaido, Hyogo, Ibaragi, Ishikawa, Iwate, Kagawa, Kagoshima, Kanagawa, Kochi, Kumamoto, Kyoto, Mie, Miyagi, Miyazaki, Nagasaki, Niigata, Oita, Okayama, Okinawa, Osaka, Saga, Shiga, Shimane, Shizuoka, Tochigi, Tokushima, Tokyo, Tottori, Toyama, Wakayama, Yamagata and Yamaguchi.

Japan-Korea trade is chosen as an application in this study because we observed that by 2006 Korea had become one of the highest intra-industry trade partners of Japan. Even when disaggregated to prefecture levels, a high degree of intra-industry trade persisted among many regions. Previous studies include traditional explanatory variables such as country GDP and differences in GDP per capita. In our investigation of what contributes to this rise in intra-industry trade, we introduce the extensive margin and intensive margin as alternative determinants of intra-industry trade. Two distinct concepts in the empirical investigation of international trade are thus merged in this paper. In particular, we tested two hypotheses: (1) that intra-industry trade between Japanese prefectures and Korea may be lowered by raising the intensity of trade for products already traded by a prefecture, if the prefecture is the net exporter of the differentiated products, and (2) that intra-industry can be strengthened by engaging in new trade for products if they are matched by imports. We confirmed our hypotheses by obtaining significant coefficients for both the extensive and intensive margins.

The structure of this paper is as follows. The next section introduces the basic concepts of the Grubel–Lloyd intra-industry trade index and the Hummels–Klenow export margins, particularly from the perspective of regional exports. Developments in international trade between Japan and Korea over the last two decades are summarized in Section 3. In Section 4, we further examine trade between Japan and Korea by investigating the intra-industry measure and extensive margins at the Japanese prefecture level. Section 5 empirically examines the determinants of prefecture intra-industry trade with Korea, using the concept of export margins in addition to traditional explanatory variables. The last section discusses our results and concludes the paper.

2. Intra-industry trade and export variety

In this section, we define key concepts and indices of intra-industry trade and export margins at sub-regional levels within a nation. After defining these indices, we propose two testable hypotheses on the relationship between intra-industry trade and export margins.

Before we introduce these key concepts, it is important to define industries, products, and varieties in this study. Industries and products in any empirical studies of international trade are dependent on the use of disaggregation levels. In this study, we use the 9-digit levels of the Harmonized System (HS).[4] For example, automobile products are separated into 6 categories depending on engine size. We use industries and products interchangeably in this study. The term variety is used for different types within a single product/industry. So an increase in variety (more types of a product) contributes to a larger trade of any particular HS 9-digit product.

2.1. Grubel–Lloyd index for sub-regional IIT and the traditional determinants of IIT

As is well documented, intra-industry trade constitutes a large portion of international trade. Kimura et al. (2007) provide evidence that parts and components trade has come to make up a large portion of international trade. One way to capture the degree of international trade made up by intra-industry trade is to measure to what extent export and import in the industry overlap. A standard measure of intra-industry trade is the Grubel and Lloyd (1975) index.[5] We choose the standard Grubel–Lloyd index over other indices to make our study more comparable to previous studies in the literature. The share of intra-industry trade between countries h and j in industry (or product) k is given by

$$\mathrm{IIT}_{hjk} = \frac{2\ \min(X_{hjk}, X_{jhk})}{X_{hjk} + X_{jhk}},$$

[4] Strictly speaking, we calculate the intra-industry trade index at the HS 6-digit level because the Ministry of Finance, at the 9-digit level, provides different codes for exports and imports even for the same product/industry.

[5] Modifications to this original Grubel–Lloyd index are also suggested to capture the effect of trade imbalance (Balassa, 1986; Bergstrand, 1983), dynamic change, and differences in relative prices between export and import; see also Helpman (1987), Loertscher and Wolter (1980) and Hummels and Levinsohn (1995). However, the original Grubel–Lloyd index is still useful for measuring the nature of intra-industry trade in empirical research.

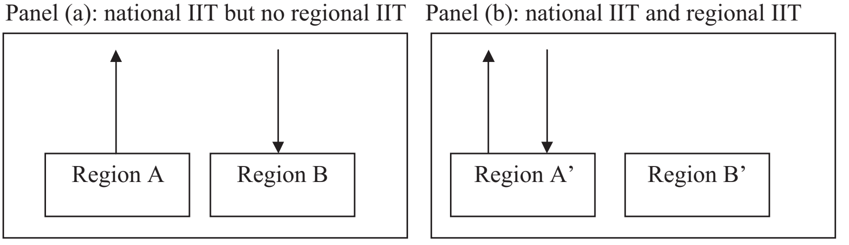

Fig. 1. Intra-industry trade at regional level. All arrows represent trade flows of products in the same industry. Arrows going up represent exports from regions, and arrows going down represent imports for regions.

where X_{hjk} is the value of exports of industry (or product) k from country h to country j. By aggregating this index over the entire K industries, we obtain an IIT index between country h and j.

$$\mathrm{IIT}_{hj} = \frac{\sum_{k=1}^{K} 2 \ \min(X_{hjk}, X_{jhk})}{\sum_{k=1}^{K} (X_{hjk} + X_{jhk})} \tag{1}$$

In the case of intra-industry trade between a foreign country and a prefecture in Japan, X_{ijk} simply denotes the export value of industry (or product) k from a prefecture i to country j. Intra-industry trade measured at the prefecture level can capture a higher proportion of trade cause by fragmentation in observed intra-industry trade.

For the ease of exposition, we present an example of a country with two regions in Fig. 1. All arrows represent the trade flows of products within the same industry. Arrows going up represent exports from regions, and arrows going down are imports for regions. Values of trade flows are all set equal. If we use a traditional Grubel–Lloyd index measured at the national level, intra-industry trade for this industry is one in both panels (a) and (b). However, if we use Grubel–Lloyd indices at the regional level, intra-industry trade is zero for region A, B and B′, while it is one for region A′. By looking at international trade at the regional level, trade flows are restricted to region A′ and two-way trade here is more likely to involve a single firm or a few related firms than two-way trade observed at the national level. We can thus attribute observed intra-industry trade in region A′ to the fragmentation of production, as do Arndt and Kierzkowski (2001). We should note that fragmentation of production does not necessarily take place even for region A′. For example, there may be one firm importing low quality varieties and another firm exporting high quality locally produced varieties, as in Flam and Helpman (1987). In the case of panel (a), we observe intra-industry trade at the national level, but not at the regional level.

A formal definition of sub-regional IIT is given below by replacing country h with sub-region i within country h:

$$\mathrm{IIT}_{ij} = \frac{\sum_{k=1}^{K} 2 \ \min(X_{ijk}, X_{jik})}{\sum_{k=1}^{K} (X_{ijk} + X_{jik})} \tag{2}$$

where X_{ijk} is exports of industry (or product) k from region i to country j. By aggregating this index over the entire K industries, we obtain a sub-regional IIT index between region i and country j.

The determinants of intra-industry trade come from many sources. Because of the love of variety, consumers demand horizontally differentiated products of similar quality from both domestic producers and foreign producers, as demonstrated by Krugman (1979). Similarly, consumers benefit from having the option to choose different qualities of products, as shown in Flam and Helpman (1987). Multinationals can also fragment some stages of their production overseas to take advantage of differences in factor requirements in each stage of production, as discussed in Jones (2000) and Arndt and Kierzkowski (2001).

In contrast to trade volume predictions made based on factor proportion theory, intra-industry trade increases with increases in similarity between two economies, resulting in more horizontal IIT (differentiated products of same quality), as demonstrated by Krugman (1979) and Lancaster (1980).

Table 1
Concentration and diversification of production location.

Case I						Case II					
	Region				National sum		Region				National sum
Product	A	B	C	D		Product	A	B	C	D	
1	15	15			30	1	10		10	10	30
2	15	15			30	2	10	10		10	30
3			15	15	30	3	10	10	10		30
4			15	15	30	4		10	10	10	30
Sum	30	30	30	30		Sum	30	30	30	30	

Note: Yoshida (2011, Table 1, pp. 607).

The continuously high rates of economic growth experienced in the last few decades by many Asian economies certainly made their economies more similar to Japan's. These Asian countries' economic growth encouraged more horizontal IIT with Japan. However, emerging economies in Asia, Latin America and Eastern Europe provide an opportunity for FDI, consequently increasing intra-firm trade and vertical IIT.

Applying standard IIT regression (between countries) to sub-regional IIT, we estimate the following regression:

$$\mathrm{IIT}_{ijt} = \alpha_i + \beta_1 \mathrm{GDP}_t^j + \beta_2 \mathrm{GDP\_PREF}_{it} + \beta_3 \mathrm{DGDPPC}_{it} + \varepsilon_{it} \tag{3}$$

where IIT_{ijt} is the sub-region IIT index between ith region and country j in year t as defined in Eq. (2). GDP_t^j is GDP (converted in terms of the Japanese yen) for country j in year t, $\mathrm{GDP\_PREF}_{it}$ is ith prefecture GDP in year t, and DGDPPC_{it} is the difference in GDP per capita between country j and ith prefecture in year t.

2.2. Hummels–Klenow indices for sub-regional export margins

There is, however, another important development in the empirical trade literature. Based on a concept developed by Feenstra (1994), Hummels and Klenow (2005) proposed a measure to capture the diversity of products a country exports. They decomposed the share of a country's exports into an *extensive margin* and an *intensive margin*.[6] The extensive margin measures the number of different types of products while the intensive margin measures the degree of export intensity for a given product.

Before we define export margin indices, let us demonstrate the importance of examining sub-regional exports by considering the following two cases in Table 1. Say a country consists of four sub-regions and exports four types of products. Each table represents, in billions of dollars, exports of the products in that row and from the region in that column. The bottom row is the sum of exports for each region, and the rightmost column represents the value of national exports for each product. We should note that these aggregate values of exports are equal between the two cases. In other words, researchers observing aggregate values at the national level could not distinguish one from the other.

When regional export data at the product level are available as in case II, however, we observe that exports of each product are diversified across more regions. While each region specializes in just half of the nation's export products in case I, each region exports three-quarters of the nation's export products in case II. If we recognize goods produced in different sub-regions within a country as distinct, differentiated products, then the greater number of products is exported in case II.

Following Hummels and Klenow (2005), we construct export margin indices for prefecture exports for both the intensive margin and the extensive margin. These indices for prefectures are calculated with respect to Japanese national exports. We denote the value of export for industry (or product) k

[6] See also Broda and Weinstein (2006) and Feenstra and Kee (2004).

from prefecture i to country j as X_{ijk}, as in the Grubel–Lloyd index. To construct these indices, reference economy m must be defined. In Feenstra (1994), the reference economy is the same economy as in the previous period, and the world economy is chosen for cross-country analysis in Hummels and Klenow (2005). Our reference economy m is Japan as a nation.

I_{ij} is the set of observable categories in which prefecture i has positive exports to country j; i.e., $X_{ijk} > 0$. I is the set of all product categories. The extensive margin and intensive margin are defined as,

$$\mathrm{EM}_{ij} = \frac{\sum_{i \in I_{ij}} X_{mjk}}{\sum_{i \in I} X_{mjk}}; \tag{4}$$

$$\mathrm{IM}_{ij} = \frac{\sum_{i \in I_{ij}} X_{ijk}}{\sum_{i \in I_{ij}} X_{mjk}}. \tag{5}$$

The extensive margin is the ratio of the subtotal of national exports for the set of products in which a prefecture has positive exports to the total number of national exports.

Extensive margins in the above examples are 0.5 in case I and 0.75 in case II. The intensive margin is the ratio of total exports of the prefecture to the subtotal of national exports for the same product categories. Intensive margins in the above examples are 0.5 in case I and 0.33 in case II. In both cases, the share of regional export in national export, i.e., 0.25, can be obtained by finding the product of the extensive margin and intensive margins.[7]

2.3. *Extensive margin and intensive margin on IIT*

The Grubel–Lloyd index is likely to be large if a prefecture specializes or concentrates in a small number of industries and has a relatively high degree of overlap of exports and imports. However, the overlap of exports and imports must cover a large number of industries if a prefecture engages in international trade for most existing industries. Because the Grubel–Lloyd index covers all types of industries, it is difficult to conclude what the determinants of higher intra-industry trade for prefectures are unless we have supplemental information that reveals the industry structures of prefectures.

We formally investigated two hypotheses with regard to the determinants of prefecture intra-industry trade. The first is that an increase in the intensity of exports in existing industries, measured as the intensive margin in Eq. (5), lowers the intra-industry trade of prefectures. The second is that an expansion of exports to new industries, measured as the extensive margin in Eq. (4), increases the intra-industry trade of prefectures.

Using the theoretical model of Helpman (1987), we develop a testable hypothesis for the effect of the intensive margin on intra-industry trade. In a two-country, two-sector (homogenous and differentiated products), two-factor, Heckscher–Ohlin-type world economy, the Grubel–Lloyd index can be shown to be,

$$\mathrm{IIT}_{ij} = \frac{sn^*}{s^*n}. \tag{6}$$

The share of the home country in world spending is denoted as s, and the number of differentiated varieties within the industry is n. The asterisk indicates a foreign country. In Eq. (6), the home country is assumed to be the net exporter of the differentiated product industry.

It is straightforward to see that an increase in n lowers intra-industry trade, ceteris paribus However, an increase in n needs to be interpreted carefully with consideration of the export margin indices in Eqs. (4) and (5). In the model of differentiated products, an increase in n is simply an increase in the number of new varieties *within the industry*. So, an increase in n should be interpreted as an increase in the intensive margin. An increase in n for the net exporter country means less of an overlap between

[7] For other cases that are observationally equivalent at the national level, one can assume that each region specializes exclusively in one of the products and exports 30 billion dollars (that is, case III) and that all regions export 30/4 billion dollars for each product (that is, case IV). Extensive margins are 0.25 and 1 for case III and case IV, respectively. Intensive margins are 1 and 0.25 for case III and case IV, respectively. See Yoshida (2011) for more discussion.

Table 2
Development of Japanese trade with Korea.

Year	Export		Import	
	Total export (trillion yen)	Korea (percentage)	Total import (trillion yen)	Korea (percentage)
1990	41.6	6.1 (3)	33.8	5.0 (5)
1993	40.3	5.3 (4)	26.8	4.9 (4)
1996	44.9	7.1 (2)	38.0	4.6 (3)
1999	47.7	5.5 (2)	35.2	5.2 (3)
2002	52.2	6.9 (3)	42.1	4.6 (3)
2005	65.8	7.9 (3)	56.8	4.7 (4)

Source: author's calculation from the Japan Custom, the Ministry of Finance.

Note: Total export(import) is the value of Japanese export(import) to the world. Figures in parentheses are the rank of Korea as a trade partner in terms of trade values.

trade flows in differentiated products. Therefore, this simple model provides the hypothesis that an increase in intensive margin decreases intra-industry trade.

In the case of the extensive margin, we have a second straightforward hypothesis. An increase in the extensive margin increases the degree of intra-industry trade if a new export variety is matched with one of the importing products.

The empirical equation is specified in the following panel data regression model:

$$\mathrm{IIT}_{ijt} = \alpha_i + \beta_1 \mathrm{GDP}_t^j + \beta_2 \mathrm{GDP\_PREF}_{it} + \beta_3 \mathrm{DGDPPC}_{it} + \beta_4 \mathrm{EXTM}_{it} + \beta_5 \mathrm{INTM}_{it} + \varepsilon_{it} \quad (7)$$

The dependent variable is IIT_{ijt}, the Grubel–Lloyd index as defined in Eq. (2), but adjusted for sub-regions. GDP_t^j, $\mathrm{GDP\_PREF}_{it}$, and DGDPPC_{it} have the same definition as they did in Eq. (3). The additional explanatory variables include the prefecture extensive margin, EXTM_{it}, and the prefecture intensive margin, INTM_{it}, with respect to Korea.

3. Overview of international trade between Japan and Korea

As an application of the above two trade indices at sub-regional levels, we empirically examine bilateral trade between Japan and Korea. Korea is chosen because of its proximity to Japan and its prominent role in Japan's international trade sector. Korea is the third most important trading partner for Japan, after the world's two economic giants, the U.S. and China. In this section, we provide an overview of trade between Japan and Korea. We summarize the growth of Japan-Korea trade, the industry composition of this trade, Japanese foreign direct investment (FDI) in Korea, and the intra-industry index between Japan and over one hundred other countries.

The total value of Japanese exports and imports, along with Korea's share and its rank among Japan's trading partners, are shown in Table 2. On the side of Japanese exports, Korea's share increased during the sample period. The observed total value of exports increased during this period; Japanese exports to Korea more than doubled in value, from 2.53 trillion yen in 1990 to 5.17 trillion yen in 2005.

On the Japanese import side, Korea's share remains relatively the same. However, in terms of trade value, Korea's share increased from 1.69 trillion yen in 1990 to 2.69 trillion yen in 2005. In 1996, Korea became the third largest partner for Japanese imports, following China and the U.S. In 2005, Korea fell behind Australia in rank due to a sharp rise in the price of natural resources over the last few years. The majority of imports from Australia are natural resources, including coal (32%), natural gas (14%) and iron ore (13%).

This study seeks to further investigate the components of Japan's international trade. For this purpose, we investigated Japan-Korea international trade using the Harmonized System 4-digit codes in 2005. One striking feature is that the "IC (HS8542)" sector appears to be the largest sector in both exports (7.4%) and imports (14.0%) between Japan and Korea. Casual observation also reveals that there are other overlapping sectors representing the largest exports and imports. This serves as crude

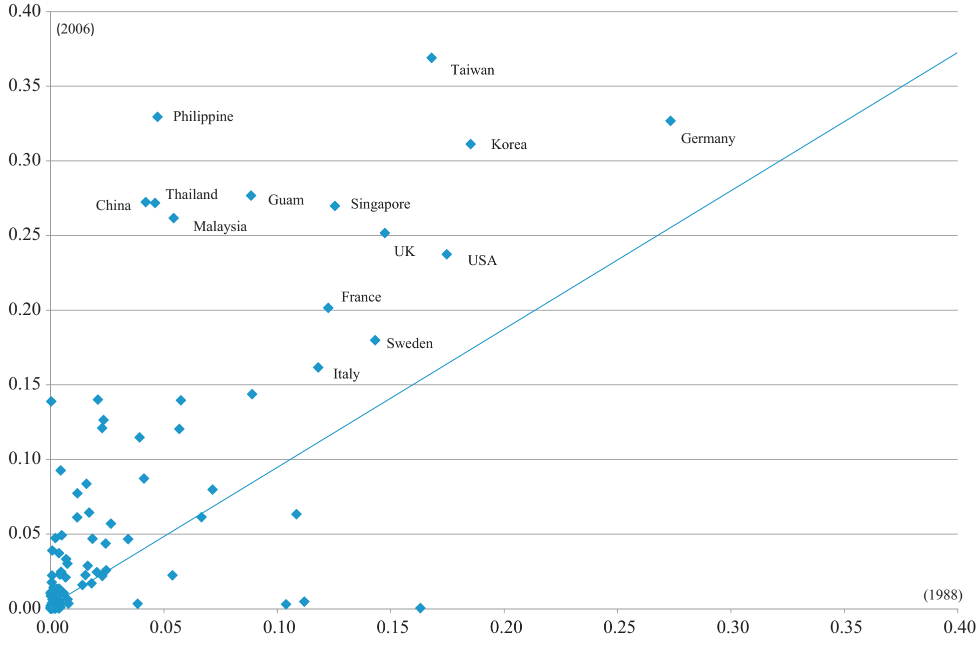

Fig. 2. Intra-industry trade: Grubel–Lloyd indices in 1988 and 2006. The Grubel–Lloyd indices are calculated using Japanese trade at the HS 6-digit level for 129 trading partners. The trade data are taken from the website of the *Japan Custom, Ministry of Finance*.

evidence of intra-industry trade between Japan and Korea. We formally investigate this issue in later sections.

The Japan Overseas Company (OJC), published by Toyo Keizai, collects FDI data based on questionnaires sent to listed companies in Japan. Based on the OJC, accumulated Japanese FDI establishments in Korea became 640 subsidiaries by 2004. Among recipients of Japanese FDI, Korea is tenth, following China (4052), the USA (3359), Malaysia (1513), Hong Kong (1121), Thailand (1067), Taiwan (910), the UK (841), Malaysia (806) and Indonesia (698).[8] By industry classifications, 21.4% of total FDI went into the electronics industry, 16.5% into the chemical and pharmaceutical industry, 15.2% into the machinery industry, 7.3% into the automobile industry, 4.6% into the precision machinery industry, 4.1% into the IT industry and 3.0% into the metal product industry. These industries are likely to engage in vertical intra-industry trade or vertical specialization.

In Fig. 2, Grubel–Lloyd indices for 129 countries are plotted for 1988 and 2006. The diagonal line traces points at which the values of the indices for the two years are equal. First, most of the countries examined experienced growth in intra-industry trade with Japan over this period. Second, countries having higher intra-industry trade with Japan in 2006 include many Asian countries as well as countries economically similar to Japan, such as European countries and the U.S. Third, growth rates for intra-industry trade in Asian countries, namely, Taiwan, Korea, the Philippines, Thailand, Malaysia and China, are the largest among all countries. This result is interesting especially when examined jointly with the work of Abe (1997), who documents that intra-industry trade between Japan and ASEAN economies has yet to be developed prior to 1990. Fourth, and most importantly for this paper, Korea was one of the largest intra-industry trading partners for Japan in 2006.

[8] In recent years (from 2001 to 2004), Japanese FDI outflows to Korea outperform Japan's FDI outflows to Taiwan and Singapore.

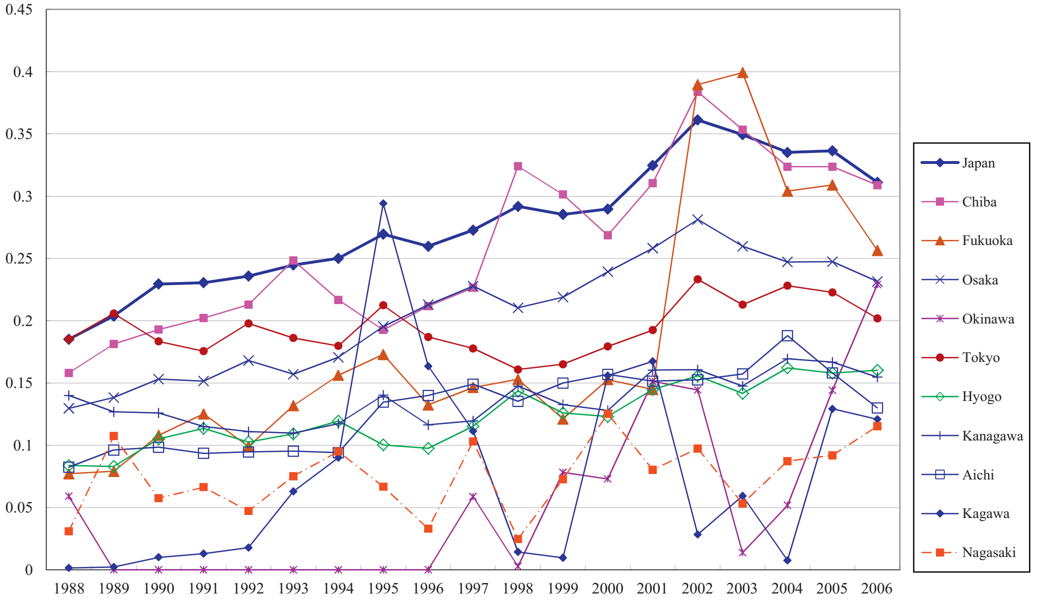

Fig. 3. Selected Japanese prefecture IIT for Korea.

4. Disaggregation of Japan-Korea trade by sub-regions

In this section, we present the Grubel–Lloyd index and Hummels–Klenow index calculated at regional level based on the methodology in Section 2.

4.1. Sub-regional intra-industry trade

Taking advantage of the disaggregated dataset of Japanese international trade of 41 regions, we measured the Grubel–Lloyd index between Japanese regions and Korea. By restricting intra-industry trade to sub-regions, this index is more likely to capture the degree of vertical intra-industry trade (related to fragmentation or the vertical specialization of firms) than the traditional index, which is based on the national level. We calculated this sub-regional Grubel–Lloyd index for 41 regions of Japan with respect to Korea for the sample period between 1988 and 2006.

In Fig. 3, the dynamic paths of intra-industry trade with Korea of ten selected prefectures, according to the Grubel–Lloyd index for Japan, are shown. The Grubel–Lloyd index for Japan reveals that its peak was 0.36 in 2002, and it shows a decline in recent years. For the prefecture Grubel–Lloyd indices, it is striking that, even when trade is broken down to the prefecture level, intra-industry trade still remains very high for some prefectures.[9] For these prefectures, we can assume that intra-industry trade is in large part caused by the fragmentation of production between Korea and Japan.

4.2. Sub-regional export margins

Following Yoshida (2011), we constructed extensive margins of prefectures for exports to Korea for the sample period. In Fig. 4, extensive margins for ten selected prefectures are shown. The investigation of extensive margins reveals striking results among prefectures with high intra-industry trade with

[9] In terms of GDP, a typical prefecture is in the size range of countries like Ecuador or Hungary. So it may not be surprising that prefectures engage largely in intra-industry trade.

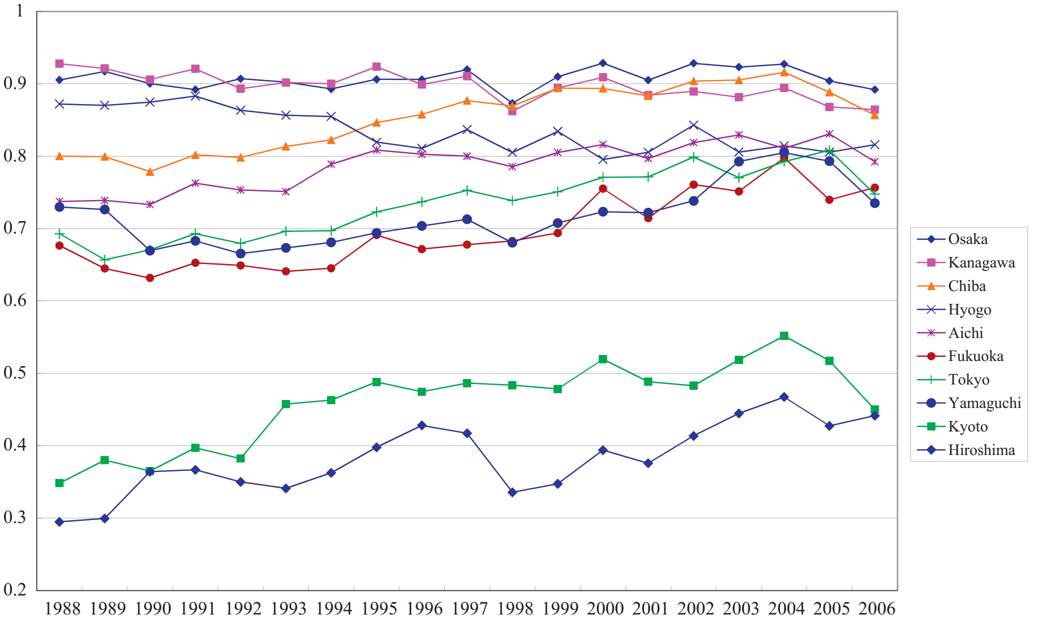

Fig. 4. Extensive margins of selected prefectures for exports to Korea.

Korea: some prefectures concentrate only on a small portion of industries while other prefectures cover most of the exporting industries. Those prefectures with a heavy concentration of manufacturing industries consistently show high levels (between 65% and 90%) of export variety to Korea, namely, Osaka, Kanagawa, Chiba, Hyogo, Aichi, Fukuoka, Tokyo and Yamaguchi.[10] Immediately following are Kyoto and Hiroshima; however, their extensive margins are substantially lower than the above group's.

As regards determinants of higher intra-industry trade, we observed two types of development for the prefecture industries. First, those prefectures able to export a wide variety of products before the 1980s intensified intra-industry trade relationships with Korea over the last two decades. Second, some prefectures expanded their production variety, especially to industries that are the most likely to require high intra-industry trade.

5. A deepening of existing trade or a growth in variety?

5.1. The data

The nominal GDP of Korea, denominated in Korean won, is taken from the *World Development Indicator* (*WDI*), the World Bank. The GDP of Korea is then converted into yen using the annual average rate of won/yen. The annual average rate of won/yen is calculated using the end-of-month rate available from the Bank of Japan. The GDP per capita of Korea at constant won is also taken from the *WDI*. This variable is also converted into Japanese yen.

The nominal GDPs of prefectures are taken from the *Annual Report on Prefectural Accounts*, the Cabinet Office, the Government of Japan. The prefecture population is taken from the *Census Population*. The prefecture GDP per capita is then calculated by dividing prefecture GDP by prefecture population.

[10] The extensive margin for a prefecture's exports to Korea is calculated with Japanese exports using Korea as a reference, so the percentage indicates the value-weighted coverage of industries.

The international trade data at the prefecture level are constructed from port level international trade data provided by the Japan Custom, Ministry of Finance. Disaggregation is at the HS 9-digit level. The basic dataset was constructed for research by Yoshida (2011).

The distance variable is calculated based on the distance from major international ports in prefectures to Seoul. The distance calculation is conducted using a Java program on John Haveman's webpage that utilizes the latitude and longitude of the two locations.

5.2. The transformation of the IIT index

The Grubel–Lloyd IIT index is constructed to fall in the range between 0 and 1. Using this index as a dependent variable in a regression violates the assumption that the error term follows a normal distribution function. One way to address this issue is to transform the original data so that the error term follows a normal distribution. The logistic transformation is widely used as a solution to this problem, for example, in Hummels and Levinsohn (1995).

However, when the original data contain a zero value, the transformed value is undefined because the logistic transformation takes the logarithmic form.[11] To get around this problem of undefined value, we suggest using the Box-Cox transformation in place of the log part of the logistic transformation. We call the following transformation (8) the Box-Cox Logistic transformation and denote it with BCL:

$$\mathrm{BCL}(y) = \frac{(y/(1-y))^{\lambda} - 1}{\lambda}, \quad \lambda \in (0, 1]. \tag{8}$$

5.3. The empirical results

The dependent variable is the Box-Cox logistic-transformed Grubel–Lloyd index. The extensive margin (EXTM) and intensive margin (INTM) are Box-Cox transformed. The parameter λ for Box-Cox is set equal to 0.1. The other explanatory variables are in logarithmic form. Estimating Eqs. (3) and (7) are applied to Japan-Korea trade and they are redefined as Eqs. (9) and (10):

$$\mathrm{IIT_{iKORt}} = \alpha_i + \beta_1 \mathrm{GDP\_KOR}_t + \beta_2 \mathrm{GDP\_PREF}_{it} + \beta_3 \mathrm{DGDPPC}_{it} + \varepsilon_{it} \tag{9}$$

$$\mathrm{IIT_{iKORt}} = \alpha_i + \beta_1 \mathrm{GDP\_KOR}_t + \beta_2 \mathrm{GDP\_PREF}_{it} + \beta_3 \mathrm{DGDPPC}_{it} + \beta_4 \mathrm{EXTM}_{it} + \beta_5 \mathrm{INTM}_{it} + \varepsilon_{it} \tag{10}$$

where $\mathrm{IIT_{iKORt}}$ is the sub-region IIT index between the ith region and Korea in year t. $\mathrm{GDP\_KOR}_t$ is GDP (converted into Japanese yen) for Korea in year t, $\mathrm{GDP\_PREF}_{it}$ is the ith prefecture GDP in year t, and DGDPPC_{it} is the difference in GDP per capita between Korea and the ith prefecture in year t. The prefecture extensive margin, EXTM_{it}, and the prefecture intensive margin, INTM_{it}, are calculated with respect to Korea. Both fixed-effects and random-effects models are used for estimating Eqs. (9) and (10). We refer to Eq. (9) as model 1 and to Eq. (10) as model 2. The estimation results are summarized in Table 3.

The fitness of regression is moderately high, with the adjusted R^2 ranging from 0.51 to 0.70 for all the models except the random-effects model for Eq. (9). The Hausman test statistics are 2.82 for model 1 and 2.76 for model 2, and we therefore do not reject the null hypothesis of consistency of random effects estimators for both models.

In model 1, the determinants of IIT traditionally used in the literature include the GDPs of the two economies and the absolute difference in GDP per capita for the two economies.[12] The estimate indicates that intra-industry trade is strengthened by the growth of Korea's GDP over the sample period. We should note that this variable may capture other cross-prefecture-invariant effects because

---

[11] Researchers may inattentively treat these zero values as missing values. However, this will, in turn, lead to biased estimates by censoring the lowest values of the original variable.

[12] The maximum and minimum values of GDP are the usual variables. Since only Tokyo exceeds Korea in terms of GDP throughout the sample period, the maximum values for GDP and *GDP_KOR* are very similar. (The GDP of Osaka (Aichi) also exceeds that of Korea in 1988, 1990 and 1993 (88).) We also estimated this model with maximum and minimum values of GDP. The qualitative results are the same as those for Model 1.

Table 3
Regression results.

	Model 1		Model 2		Model 3
	Fixed	Random	Fixed	Random	Random
GDP_KOR	1.173***	1.337***	0.420**	0.519***	0.520***
	(0.194)	(0.214)	(0.164)	(0.198)	(0.198)
GDP_PREF	3.769**	1.352***	0.749	−0.710**	−0.507
	(1.486)	(0.364)	(1.325)	(0.315)	(0.335)
DGDPPC	−0.015	0.839**	−0.224	0.289	0.226
	(0.728)	(0.414)	(0.666)	(0.361)	(0.361)
EXTM			1.321***	1.288***	1.253***
			(0.149)	(0.097)	(0.098)
INTM			−0.285	−0.332***	−0.350***
			(0.189)	(0.000)	(0.110)
DIST					−1.082
					(0.361)
Observations	717	717	710	710	710
No. of prefectures	41	41	41	41	41
adj. R^2	0.64	0.23	0.70	0.51	0.52
Hausman:					
CHISQ		2.82		2.76	
p-Value		0.42		0.73	

Note: The dependent variable is the Box-Cox logistic transformed Grubel–Lloyd index. The extensive margin (EXTM) and intensive margin (INTM) are Box-Cox transformed. The parameter lambda for Box-Cox is set equal to 0.1. The other explanatory variables are in logarithmic form. Figures in parentheses are standard errors (heteroskedasticity-consistent for fixed model). The Hausman statistics tests the null of consistency of random effect estimates and given as CHISQ.

* Statistical significance at 10%.
** Statistical significance at 5%.
*** Statistical significance at 1%.

the GDP of Korea is the same for any prefecture's Grubel–Lloyd index in a given year. The GDP of prefectures and the difference in GDP per capita are not statistically significant. This result is not surprising given that prefectures such as Fukuoka, Chiba and Okinawa have much lower incomes than Tokyo, accounting for higher intra-industry trade with Korea (see Fig. 3). The results for these three variables remain qualitatively the same as the results in the other models.

Next, the extensive margin of prefecture exports is shown to affect intra-industry trade, and the point estimates are quite robust in both estimation specifications. This result implies that a new product of prefecture export is chosen from the existing products of prefecture import or matched by the simultaneous creation of imports for the same product classifications.

An increase in the intensive margin of a prefecture, however, decreases intra-industry trade. This negative effect provides consistent evidence for our theoretical hypothesis described above. This finding can be interpreted to mean that an increase in the intensive margin is caused by the creation of new varieties in categories for which prefectures are net exporters.

5.4. Robustness

Lastly, as a robustness check, we include a variable for distance in a random effects regression.[13] A distance variable is often included in IIT regressions in the literature to reflect the higher likelihood of larger trade between two closely located regions, as is the case in the Gravity model for general trade regressions.[14] Model 3 in Eq. (11) includes all explanatory variables in model 2 and distance variable,

[13] Because the distance variable is time-invariant, it cannot be used in the fixed-effects regression model.
[14] Bergstrand and Egger (2010) derives the theoretical based gravity-type equations for final products, foreign direct investments, and intermediate goods trade.

but only random-effects estimation is used.

$$\mathrm{IIT}_{\mathrm{iKORt}} = \alpha_{\mathrm{i}} + \beta_1 \mathrm{GDP\_KOR}_t + \beta_2 \mathrm{GDP\_PREF}_{it} + \beta_3 \mathrm{DGDPPC}_{it} + \beta_4 \mathrm{EXTM}_{it} + \beta_5 \mathrm{INTM}_{it} + \mathrm{DIST}_i + \varepsilon_{it} \tag{11}$$

where $DIST_i$ is the distance between Seoul and the major international port in prefecture i.

Inclusion of distance does not affect the qualitative findings of previous models. Korean GDP, extensive margins, and intensive margins are statistically significant at the 1% level. It is noteworthy that the coefficients of extensive and intensive margins are only slightly changed. The distance variable estimate is not statistically significant although it is negative, which is consistent with the expected sign.

6. Discussion and conclusion

We observed that Korea had become one of the highest intra-industry trade partners of Japan by 2006. Even when disaggregated to prefecture levels, a high degree of intra-industry trade persisted among many regions. We tested two hypotheses: (1) that intra-industry trade between Japanese prefectures and Korea may be lowered by raising the intensity of trade for the products a prefecture has already traded, given that the prefecture is the net exporter of the differentiated products and (2) that intra-industry can be strengthened by engaging in new trade for products if matched by imports. We confirmed our hypotheses by obtaining significant coefficients for both extensive and intensive margins.

Our approach is distinct from previous analyses of intra-industry trade that focus on the determinants of intra-industry trade by estimating a Grubel–Lloyd-type index on the GDP of countries and the difference in GDP per capita along with other explanatory variables, as in Greenaway et al. (1994) and Greenaway, Hine, and Milner (1995). We introduced the extensive margin and intensive margin as alternative determinants of intra-industry trade. Two distinct literatures of empirical investigation of international trade are thus merged in this paper.

Although our approach provides new insights into the investigation of intra-industry trade in terms of fragmentation, there remain some caveats. First, the definition of region in this paper is arbitrary. It may suit our purposes better to define the area more narrowly, perhaps using city boundaries. Second, some firms located near prefecture borders may choose to export from ports located in neighboring prefectures. This is especially true for six prefectures that either lack international ports within their regions or do not report positive trade. Third, we can never rule out the possibility of intra-industry trade being caused by consumers' preferences for different qualities, as is assumed in Flam and Helpman (1987), even when we restrict our regions to a very small size. Further refinement of our approach needs to be considered in the future; however, we doubt that it would change the qualitative nature of our empirical results.

Lastly, we note a possible link between our study and intra-firm trade. Fukakusa and Kimura (2002) examine intra-firm trade in US and Japanese multinationals. Using the Ministry of International Trade and Industry survey, they document that intra-firm trade of Japanese firms makes up 23.9% of their exports and 25.7% of their imports in 1994. In the IIT literature, vertical intra-industry trade is disentangled from horizontal intra-industry trade by the relative price of export to import in the sector. A high value of vertical IIT is sometimes interpreted as evidence of intra-firm trade. However, at the national level, exports and imports may not have a direct link in some sectors, even if the vertical IIT index indicates a significantly large value. For example, an exporting firm *A* in the industry exports to Korea, and another firm *B*, which has no transactions either directly or indirectly with firm A, imports from Korea. By using prefecture levels of trade, we substantially narrowed the size of the region in which export and import simultaneously occur. The average size of the prefecture is close to 2% of the area of Japan. In terms of probability, our approach is more likely to link the evidence of intra-industry trade with the evidence of intra-firm trade. In this sense, our empirical evidence that prefecture intra-industry trade is significantly large between Japan and Korea may have captured some intra-firm trade between Japan and Korea.

Acknowledgements

We are grateful to two anonymous referees for their helpful comments. We also thank Chul Chung, Taegi Kim, Youngrok Kim and other participants at the Japanese Association of Applied Economics conference, the Korea and the World Economy VII conference, and the KIEP seminar for their helpful comments. This work is financially supported by JSPS KAKENHI Grant Number 20530227.

References

Abe, S. (1997). Trade and investment relations of Japan and ASEAN in a changing global economic environment. *Kobe Economic and Business Review*, *42*, 11–54.

Amador, J., & Cabral, S. (2009). Vertical specialization across the world: A relative measure. *North American Journal of Economics and Finance*, *20*, 267–280.

Ando, M. (2006). Fragmentation and vertical intra-industry trade in East Asia. *North American Journal of Economics and Finance*, *17*, 257–281.

Arndt, S. W., & Kierzkowski, H. (2001). *Fragmentation: New production patterns in the world economy*. Oxford: Oxford University Press.

Athukorala, P., & Yamashita, N. (2006). Production fragmentation and trade integration: East Asia in a global context. *North American Journal of Economics and Finance*, *17*, 233–256.

Balassa, B. (1986). Intra-industry specialization: A cross-country analysis. *European Economic Review*, *30*, 27–42.

Bergstrand, J. H. (1983). Measurement and determinants of intra-industry international trade. In P. K. M. Tharakan (Ed.), *Intra-industry trade: Empirical and methodological aspects* (pp. 201–253). Amsterdam: North Holland.

Bergstrand, J. H., & Egger, P. (2010). A general equilibrium theory for estimating gravity equations of bilateral FDI, final goods trade and intermediate trade flows. In P. van Bergeijk, & S. Brakman (Eds.), *The gravity model in international trade—Advances and applications* (pp. 29–70). Cambridge: Cambridge University Press.

Broda, C., & Weinstein, D. E. (2006). Globalization and the gains from variety. *Quarterly Journal of Economics*, *121*(2), 541–585.

Feenstra, R. C. (1994). New product varieties and the measurement of international prices. *American Economic Review*, *84*(1), 157–177.

Feenstra, R. C., & Kee, H. K. (2004). On the measurement of product variety in trade. *American Economic Review Papers and Proceedings*, *94*(2), 145–149.

Flam, H., & Helpman, E. (1987). Vertical product differentiation and North-South trade. *American Economic Review*, *77*(5), 810–822.

Fukakusa, F., & Kimura, F. (2002). Globalization and intra-firm trade: Further evidence. In P. Lloyd, & H. H. Lee (Eds.), *Frontiers of research in intra-industry trade* (pp. 237–272). New York: Palgrave Macmillan.

Greenaway, D., Hine, R., & Milner, C. (1994). Country-specific factors and the pattern of horizontal and vertical intra-industry trade in the UK. *Weltwirtschaftliches Archiv*, *130*(1), 77–100.

Greenaway, D., Hine, R., & Milner, C. (1995). Vertical and horizontal intra-industry trade: A cross industry analysis for the United Kingdom. *The Economic Journal*, *105*(433(November)), 1505–1518.

Grubel, H., & Lloyd, P. (1975). *Intra-industry trade: The theory and measurement of international trade in differentiation products*. London: The Mcmillan Press.

Helpman, E. (1987). Imperfect competition and international trade: Evidence from fourteen industrial countries. *Journal of the Japanese and International Economics*, *1*(1), 62–81.

Hummels, D., Ishii, J., & Yi, K.-M. (2001). The nature and growth and vertical specialization in world trade. *Journal of International Economics*, *54*(1), 75–96.

Hummels, D., & Klenow, P. J. (2005). The variety and quality of a nation's exports. *American Economic Review*, *95*(3), 704–723.

Hummels, D., & Levinsohn, J. (1995). Monopolistic competition and international trade: Reconsidering the evidence. *Quarterly Journal of Economics*, *110*(3), 799–836.

Jones, R. W. (2000). *Globalization and the theory of input trade*. Cambridge: MIT Press.

Krugman, P. (1979). Increasing returns, monopolistic competition, and international trade. *Journal of International Economics*, *9*(4), 469–480.

Kimura, F., Takahashi, Y., & Hayakawa, K. (2007). Fragmentation and parts and components trade: Comparison between East Asia and Europe. *The North American Journal of Economics and Finance*, *18*, 23–40.

Koopman, R., Powers, W., Wang, Z., & Wei, S.-J. (2011). *Give credit to where credit is due: Tracing values added in global production chains*, HKIMR Working Paper, No. 31.

Lancaster, K. (1980). Intra-industry trade under perfect monopolistic competition. *Journal of International Economics*, *10*, 151–176.

Loertscher, R., & Wolter, F. (1980). Determinants of intra-industry trade: Among countries and across industries. *Weltwirtschaftliches Archiv*, *116*(2), 289–293.

Murshed, S. M. (2001). Patterns of East Asian trade and intra-industry trade in manufactures. *Journal of the Asia Pacific Economy*, *6*(1), 99–123.

Yoshida, Y. (2011). An empirical examination of export variety: Regional heterogeneity within a nation. *The World Economy*, *34*(4), 602–622.