DISCUSSION PAPER
August 2008

No.32

Intra-Industry Trade Between Japan and Korea: Vertical Intra-Industry Trade, Fragmentation and Export Margins

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Abstract

This paper contributes to the existing empirical investigation of Japan-Korea international trade by providing new evidence of intra-industry trade between Korea and Japanese sub-regions. Taking advantage of a Japanese international trade dataset disaggregated by sub-regions, we calculate the Grubel-Lloyd intra-industry trade index for 41 regions of Japan with respect to Korea for the period between 1988 and 2006. By restricting the flows of intra-industry trade to sub-regions, the Grubel-Lloyd index is more likely to capture the effect of the fragmentation of production than the traditional index, which is based on the national level. By using Japanese prefecture international trade data, it is revealed that intra-industry trade is still pervasive even when it is restricted to trade flows between prefectures and Korea. In intra-industry trade regression models, we introduce extensive and intensive margins of prefecture exports as new explanatory variables. We find that a rise in 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 already exported.

Keywords: Export variety; Fragmentation; Intra-firm trade; Intra-industry trade; Regional trade; Japan; Korea.

JEL Classification Codes: F14

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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 the recent development in intra-industry trade. For example, Kimura et al. (2007) observed 1,000 % 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 part 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.

Intra-industry trade due to international fragmentation of production by its nature must be vertical, whereas intra-industry due to consumers' preferences for larger variety is horizontal (Krugman, 1979). In addition, vertical intra-industry trade for other reasons can be also observed. Consumers benefit from having options to choose from different set of qualities (Flam and Helpman, 1987). A high income country exports high quality products while importing low quality products of the same kind.

One way to measure vertical intra-industry trade is to use the threshold value of relative unit values of exports and imports (Greenaway et al., 1994). However, we cannot be sure whether vertical intra-industry trade is caused by consumers' tastes for different quality or fragmentation of production. A more direct way to capture the degree of fragmentation is to use firm-level datasets. At the firm level, we can identify two flows of trade to be part of fragmentation of production if a trade flow coming out of a firm is later matched by an incoming trade flow of the same product group, and vice versa.

Alternatively, instead of requesting firm-level observations, we suggest a methodology to restrict trade flows to a much smaller region than a country. Intra-industry trade measured by this methodology can reflect a higher proportion of trade caused by fragmentation in observed intra-industry trade[1].

Our analysis depends heavily on the international trade data of Japan provided by the Japan Custom, Ministry of Finance (JCMF). The dataset of the JCMF classifies traded products using 9-digit classifications and includes over 7,000 codes in export and over 8,000 codes in imports. The first six digits

[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.

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 the international trade dataset for prefectures. Because some prefectures either have no international ports or reported no positive international trade, we have data for 41 out of 47 existing prefectures[2]. The sample covers the period from 1988 to 2006.

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, especially from the perspective of regional exports. The developments of international trade in Japan in 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 the 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. The Measurement of Intra-Industry Trade and Export Variety

In this paper, we empirically examine the bilateral trade development between Japan and Korea in the last two decades, particularly by focusing on intra-industry trade and export margins of trade. In this section, we describe these two key concepts and the indices used in the empirical section of this paper.

Grubel-Lloyd Index for Intra-Industry Trade

Intra-industry trade, as is well documented, 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 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[3]. The share of

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[2] 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, Ohita, Okayama, Okinawa, Osaka, Saga, Shiga, Shimane, Shizuoka, Tochigi, Tokushima, Tokyo, Tottori, Toyama, Wakayama, Yamagata and Yamaguchi.

[3] Modifications to this original Grubel-Lloyd index are also suggested to capture the effect of trade imbalance, dynamic change, and differences in relative prices between export and

intra-industry trade between countries *i* and *j* in industry *k* is given by

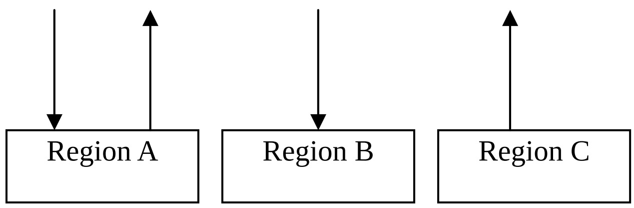
$$IIT_{ijk} = \frac{2\min(X_{ijk}, X_{jik})}{X_{ijk} + X_{jik}},$$

where X_{ijk} is exports of industry *k* from country *i* to country *j*. By aggregating this index over the entire K industries, we obtain an IIT index between country *i* and *j*.

$$IIT_{ij} = \frac{\sum_{k=1}^{K} 2\min(X_{ijk}, X_{jik})}{\sum_{k=1}^{K} X_{ijk} + X_{jik}} \qquad (1)$$

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

Figure 1. Intra-industry trade at regional level



For the ease of exposition, we present an example of a country with three regions in Figure 1. All arrows represent trade flows of products in 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 to equal size. If we use a traditional Grubel-Lloyd index measured at the national level, intra-industry trade for this industry is one. However, if we use Grubel-Lloyd indices at the regional level, intra-industry trade is zero for region B and region C, while it is one for region A. Since trade flows are restricted to region A, two-way trade here is more likely to involve a single firm or a few related firms

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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.

than two-way trade observed at national level. We can thus relate observed intra-industry trade in region A to fragmentation of production.

Hummels-Klenow Indices for Export Margins

There is, however, another important development in the empirical trade literature. Based on the concept developed in 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 *extensive margin* and *intensive margin*[4]. Extensive margin measures the degree of variety the number of different types of products, while 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. Say a country consists of four sub-regions and exports four kinds of products. Each figure 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.

Figure 2. Concentration and diversification of production location

Case I

	Region				National
product	A	B	C	D	sum
1	15	15			30
2	15	15			30
3			15	15	30
4			15	15	30
sum	30	30	30	30	

Case II

	Region				National
product	A	B	C	D	sum
1	10		10	10	30
2	10	10		10	30
3	10	10	10		30
4		10	10	10	30
sum	30	30	30	30	

Note: This figure was originally used in Yoshida (2007).

When regional export data at the product level are available, however, we can observe that exports of each product are diversified among more regions in case II. 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

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

within a country as distinct differentiated products, the variety of exports is more expansive in case II.

Following Hummels and Klenow (2005), we construct export margin indices for prefecture exports for 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 product *k* from prefecture *i* to country *j* as X_{ijk}, as in the Grubel-Lloyd index. In order to construct these indices, reference economy *m* needs to be defined. For the case of 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

$$EM_{ij} = \frac{\sum_{i \in I_{ij}} X_{mjk}}{\sum_{i \in I} X_{mjk}}; \qquad (2)$$

$$IM_{ij} = \frac{\sum_{i \in I_{ij}} X_{ijk}}{\sum_{i \in I_{ij}} X_{mjk}}. \qquad (3)$$

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 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 export 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 extensive margin and intensive margin[5].

3. Overview of International Trade of Japan with Korea in the Last Twenty Years

[5] 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.

In this section we provide an overview of trade between Japan and Korea over the last two decades. Korea is the third most important trading partners for Japan, just after the two economic giants, the U.S. and China. We present the summary of the growth for Japan-Korea trade, the industry composition of this trade, the Japanese foreign direct investment (FDI) in Korea, and the intra-industry index between Japan and over one hundred countries.

Exports and Imports

The total values of Japanese exports and imports, along with the share of Korea and its rank among Japanese trading partners, are shown in Table 1. On the side of Japanese exports, the share of Korea 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 import side of Japan, the share of Korea remains relatively the same. However, in terms of trade value, it increased from 1.69 trillion yen in 1990 to 2.69 trillion yen in 2005. Korea became the third largest partner since 1996 for Japanese imports, following China and the U.S. The rank of Korea in 2005 comes after Australia due to a sharp rise in the price of natural resources in recent years. The majority of imports from Australia are natural resources, including coal (32 percent), natural gas (14 percent) and iron ore (13 percent).

Table 1. Development of Japanese Trade with Korea

	Export		Import	
	(Trillion Yen)	(percentage)	(Trillion Yen)	(percentage)
Year	Total Export	Korea	Total Import	Korea
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)

Note: Total export(import) is the value of Japanese export(import) to the world. Figures in parenthesis are the rank of Taiwan as a trade partner in terms of trade values. (Source: author's calculation from the Japan Custom, the Ministry of Finance)

It is of interest to this research to further investigate the components of these trades. For this purpose, we investigated Japan-Korea international trade using the Harmonized System 4-digit codes in 2005. The five sectors with the largest trade values in exports from Japan to Korea include the following: “IC (HS8542)” makes up 7.4 percent of total exports; “other machineries not appearing in other 4-digits in HS84 (HS8479)” is 5.9 percent; “flat-rolled products of iron and other non-alloy steel, width greater than 600mm (HS7208)” is 5.2 percent; “cyclic hydrocarbons (HS2902)” is 2.8 percent; “optical fibers and cables, sheets and plates of polarizing mat, and lenses (HS9001)” is 2.5 percent. Other large sectors of Japanese exports to Korea include products related to precision machinery, IC and computers, steel and other metal products, electronics and chemicals.

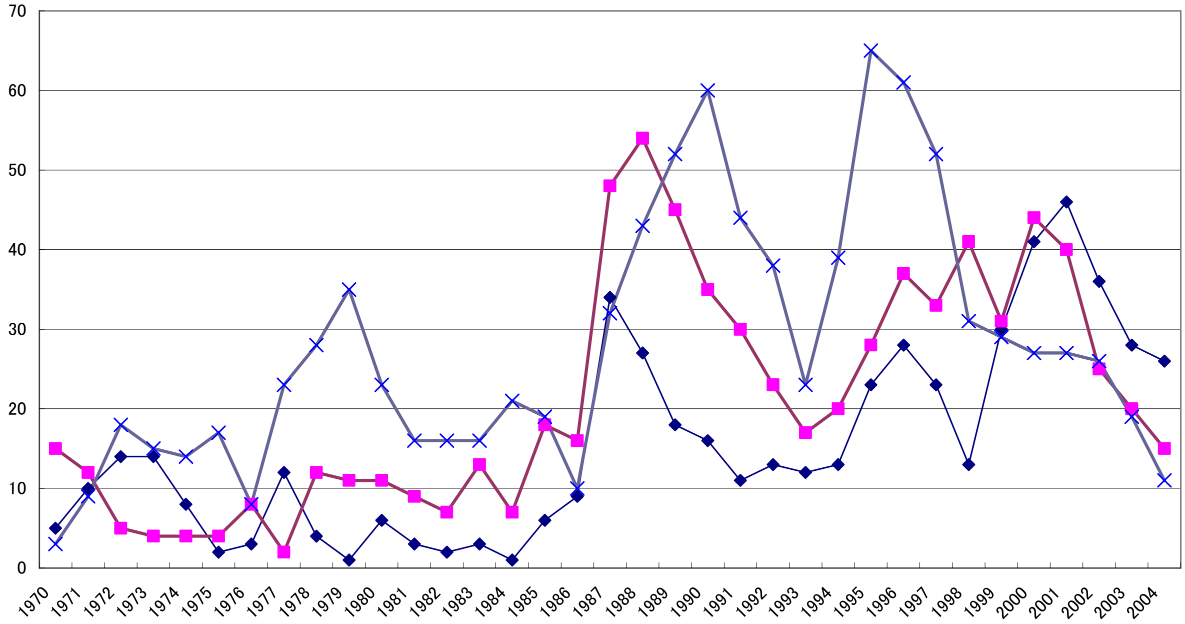
The five largest sectors in imports from Korea are the following: “IC (HS8542)” is 14.0 percent; “petroleum oil and oils obtained from bituminous minerals excluding crude (HS2710)” is 12.1 percent; “liquid crystal devices and other optical appliances not appearing in other 4-digits in HS90 (HS9013)” is 4.0 percent; “parts and accessories for computers and others in HS8469-8472 (HS8473)” is 3.8 percent; “parts for transmission, radar, radio and television (HS8529)” is 3.8 percent. Other large sectors in Japanese imports from Korea include products related to steel and other metal products, computers, molding boxes, parts of motor vehicles and chemicals.

The striking feature is that the IC sector appears as the largest sector in both exports and imports between Japan and Korea. Casual observation also reveals that there are other overlapping sectors among the largest exports and imports. This is crude evidence of intra-industry trade between Japan and Korea. We formally investigate this issue in later sections.

Japanese FDI into Korea

The Japan Overseas Company (OJC), published by Toyo Keizai, collects the 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 hosts to Japanese FDI, Korea is tenth, following China (4052), USA (3359), Malaysia (1513), Hong Kong (1121), Thailand (1067), Taiwan (910), UK (841), Malaysia (806) and Indonesia (698). 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.

Figure 3. Japanese FDI in Korea and other Asian Economies
(Number of New Establishments)



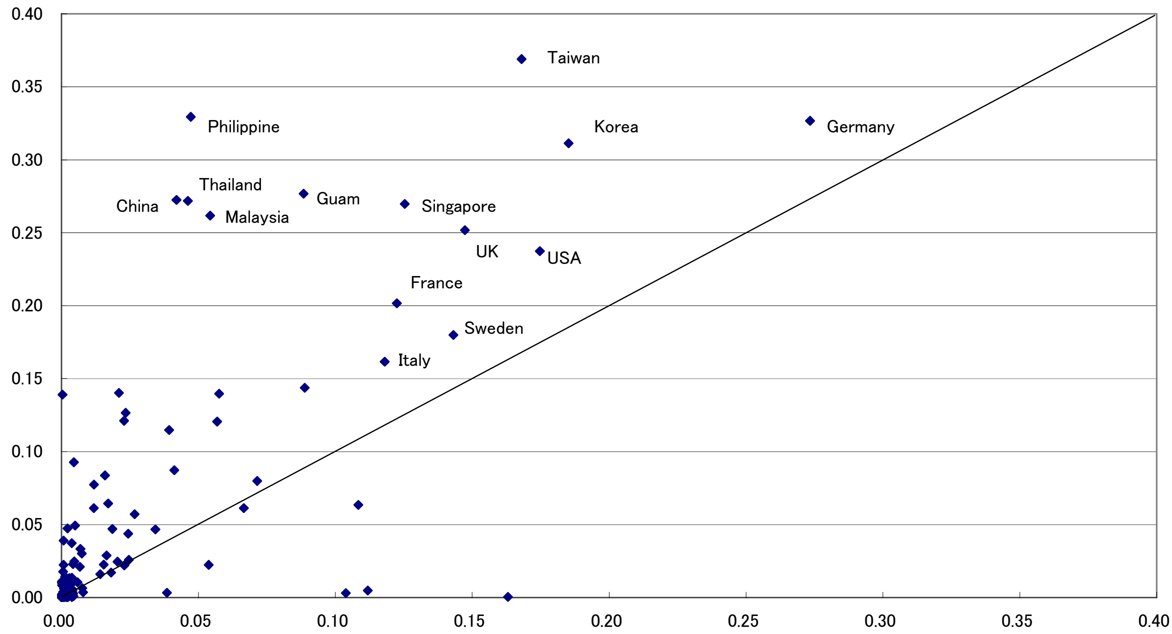
(Source: *The Japan Overseas Company*, Toyo Keizai)

Figure 3 indicates the number of new establishments of Japanese subsidiaries in Korea and other NIES. Despite the fact that Korea possesses the two advantages, of being a larger economy and closer to Japan, Korea underperformed Taiwan and Singapore as a host of incoming flows of direct investments for the entire period, except for a few recent years.

Intra-Industry Trade Between Japan and Korea

In Figure 4, Grubel-Lloyd indices for 129 countries are plotted for 1988 and 2006. The diagonal line traces points at which the values of indices in the two years are equal. First, most of the countries examined experienced growth in intra-industry trade with Japan over the period. Second, countries having higher intra-industry trade in 2006 with Japan include many Asian countries as well as countries economically similar to Japan, such as European countries and the U.S. Third, growth rates of intra-industry trade of Asian countries, namely, Taiwan, Korea, the Philippines, Thailand, Malaysia and China, are the largest among all countries. Fourth, and most importantly for this paper, the intra-industry trade of Korea is one of the largest countries for Japan in 2006.

Figure 4. Intra-Industry Trade: Grubel-Lloyd indices in 1988 and 2006



(Note: The Grubel-Lloyd indices are calculated using Japanese trade at the HS 9-digit level for 129 trading partners. The trade data are taken from the website of the *Japan Custom, Ministry of Finance*.)

4. Disaggregation of Japan-Korea Trade by Sub-regions

Prefecture Intra-Industry Trade

Taking advantage of the disaggregated dataset of Japanese international trade of 41 regions, we measured the Grubel-Lloyd index between the Japanese regions and Korea. By restricting intra-industry trade to sub-regions, this index is more likely to capture the degree of intra-firm trade 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 Figure 5, 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 the decline in recent years. For prefecture Grubel-Lloyd indices, it is striking that, even when trade is broken down into the prefecture level, intra-industry trade still remains very high for some prefectures. For these prefectures, we can assume that intra-industry trade is in large part caused by fragmentation of production between Korea and Japan.

Figure5. Selected Japanese Prefecture IIT for Korea

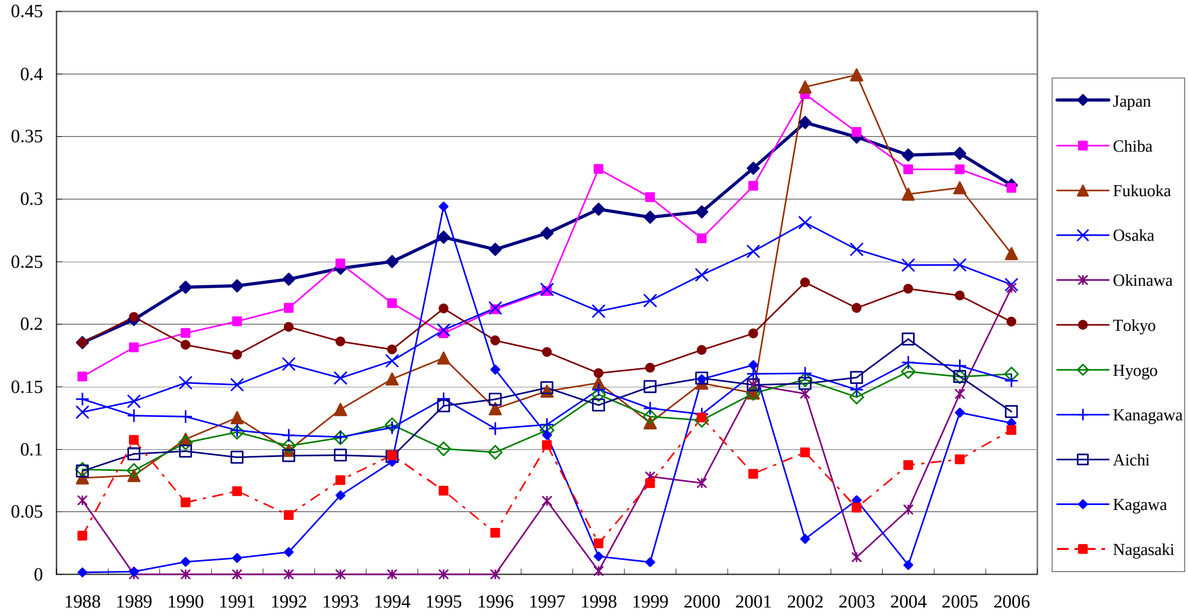
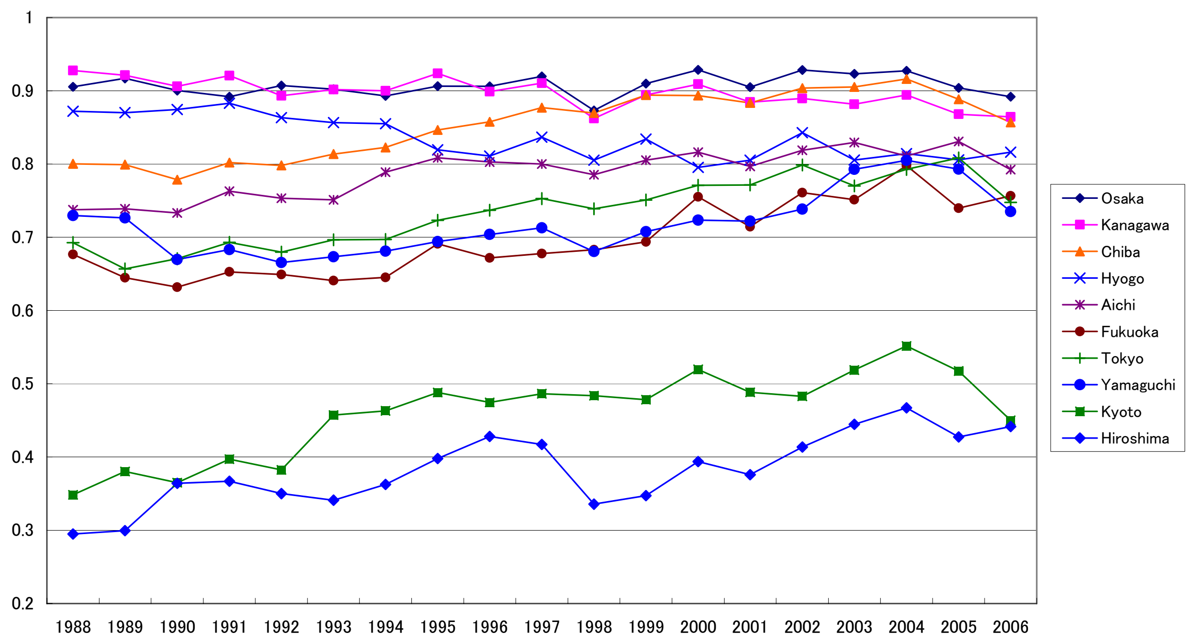


Figure 6. Extensive Margins of Selected Prefectures for Exports to Korea



Prefecture extensive margins and intensive margins

Following Yoshida (2008), we constructed extensive margins of prefectures for exports to Korea for the sample period. In Figure 6, extensive margins for ten selected prefectures are shown. The investigation of extensive margins reveals striking results among prefectures with high intra-industry trade with Korea: some prefectures concentrate only on a small portion of industries, while other prefectures cover most of the exporting industries. Those prefectures with 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[6]. 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 of 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 likely to require high intra-industry trade.

5. A Deepening of Existing Trade or a Growth in Variety?

The traditional determinants of IIT

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

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

The continuous 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 between them and Japan. However, emerging economies in Asia, Latin America and Eastern Europe provide an opportunity for FDI, consequently increasing intra-firm trade and vertical IIT.

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[6] 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.

$$IIT_{it} = \alpha_i + \beta_1 GDP\_KOR_t + \beta_2 GDP\_PREF_{it} + \beta_3 DGDPPC + \varepsilon_{it} \tag{4}$$

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. Since the Grubel-Lloyd index covers all kinds 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 determinants of prefecture intra-industry trade. The first is that an increase in intensity of exports in existing industries, measured as intensive margin in equation (3), lowers intra-industry trade of prefectures. The second is that an expansion of exports to new industries, measured as extensive margin in equation (2), increases intra-industry trade of prefectures.

From the theoretical model of Helpman (1987), we can develop a testable hypothesis for the effect of 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

$$IIT_{ij} = \frac{sn^*}{s^* n}. \tag{5}$$

The share of the home country in world spending is denoted as *s*, and the number of differentiated product varieties is *n*. The asterisk indicates a foreign country. In equation (5), 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, given *ceteris paribus*. However, an increase in *n* needs to be interpreted carefully with association to export margin indices in equations (2) and (3). In the model of differentiated products, an increase in *n* is not the creation of new industries but simply of new varieties *within the industry*. So, an increase in *n* should be interpreted as an increase in intensive margin instead of extensive margin. A larger *n* for the net exporter country means less overlap of 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 extensive margin increases the degree of intra-industry trade if a new export variety is matched with one of the importing products.

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

$$\begin{aligned} IIT_{it} &= \alpha_i + \beta_1 GDP\_KOR_t + \beta_2 GDP\_PREF_{it} + \beta_3 DGDPPC \\ &+ \beta_4 EXTM_{it} + \beta_5 INTM_{it} + \beta_6 DIST + \varepsilon_{it} \end{aligned} \quad . \qquad (6)$$

The dependent variable is IIT_{it}, the Grubel-Lloyd index, defined in equation (1). The explanatory variables include prefecture extensive margin, $EXTM_{it}$, and prefecture intensive margin, $INTM_{it}$, with respect to Korea.

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 of error term following a normal distribution function. One way to handle this problem 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[7]. 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 (7) the Box-Cox Logistic transformation and denote it with BCL:

$$BCL(y) = \frac{\left(\frac{y}{1-y}\right)^{\lambda} - 1}{\lambda} \qquad \lambda \in (0,1]. \qquad (7)$$

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 in terms of yen by the annual average rate of won/yen. The annual average rate of won/yen is calculated from the end-of-month rate from

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

the Bank of Japan. The GDP per capita of Korea at constant won is also taken from the *WDI*. This variable is also converted in terms of the 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.

The international trade data at the prefecture level are constructed from port level international trade data provided by the Japan Custom, Ministry of Finance. The basic dataset was constructed for research in Yoshida (2008).

The distance variable is calculated based on the distance of major international ports in prefectures from 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.

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.

Both fixed-effect and random effect models are used for estimating equations (4) and (6). We call equation (4) ad model 1 and use models 2 and 3 for equation (6). Because distance is a time-invariant variable, it cannot be estimated with the fixed-effect model. Model 2 is equation (6) without the distance variable. Model 3 includes all explanatory variables in equation (6), but only random-effect estimation is used. The estimation results are summarized in Table 2.

The fitness of regression is moderately high, with the adjusted R^2 ranging from 0.51 to 0.70 for all the models except model 1, the random-effect model for equation (6). The Hausman test statistics are 2.12 for model 1 and 7.25 for model 2 and do not reject the null hypothesis of consistency of random effect estimators for both models.

In model 1, determinants of IIT traditionally used in the literature are included: the GDPs of the two economies and the absolute difference of GDP per capita for the two economies[8]. The estimate indicates that intra-industry

[8] The maximum and minimum of GDP are the usual variables. Since only Tokyo exceeds Korea in terms of GDP throughout the sample period, the maximums of 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 of GDP. The qualitative results are same as those for model 1.

trade is strengthened by the growth of the GDP of Korea over the sample period. We should note that this variable may capture the other cross-prefecture-invariant effects since 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 the GDP per capita are not statistically significant. This result is not surprising since prefectures such as Fukuoka, Chiba and Okinawa have much lower incomes than Tokyo, accounting for higher intra-industry trade with Korea (see Figure 4). The results for these three variables remain qualitatively the same in other models.

Table2. Regression Results

	Model 1		Model 2		Model 3
	Fixed	Random	Fixed	Random	Random
GDP_KOR	2.216***	2.080***	0.695**	0.719***	0.746***
	(0.288)	(0.288)	(0.281)	(0.267)	(0.266)
GDP_PREF	1.590	-0.313	-4.730	-0.806	-0.983
	(5.430)	(2.115)	(4.742)	(1.764)	(1.748)
DGDPPC	-1.498	0.902	3.960	0.110	0.316
	(5.171)	(1.168)	(4.482)	(0.970)	(0.967)
EXTM			1.278***	1.243***	1.204***
			(0.157)	(0.100)	(0.102)
INTM			-0.294	-0.339***	-0.358***
			(0.184)	(0.000)	(0.109)
DIST					-1.164
					(0.967)
Observations	717	717	710	710	710
No. of prefectures	41	41	41	41	41
adj. R^2	0.65	0.23	0.70	0.51	0.52
Hausman: CHISQ		2.12		7.25	
p-value		0.55		0.20	

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 lamda for Box-Cox is set equal to 0.1. The other explanatory variables are in logarithmic form. Figures in parenthesis are standard errors (heteroskedasticity-consistent for fixed model). The Hausman statistics, given as CHISQ, tests the null of consistency of random effect estimates. Statistical significance at one, five, and ten percent are indicated by ***, **, and *, respectively.

Next, the extensive margin of prefecture exports is shown to affect intra-industry trade, and the point estimates are quite robust in any estimation models. 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 can be interpreted to mean that an increase in intensive margin is caused by the creation of new variety within categories for which prefectures are net importers. Lastly, the estimate of distance variable is not statistically significant.

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 mounted 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 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 the products if matched by imports. We confirmed our hypotheses by obtaining significant coefficients for both extensive and intensive margins.

Our approach is distinguished 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, 1995). We introduced the extensive margin and intensive margin as alternative determinants of intra-industry trade. Two different literatures of empirical investigation of international trade are thus merged in this paper.

Although our approach provides a new insight 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 under study more narrowly, perhaps as the city. Second, some firms located near the prefecture borders may choose to export from the ports located in other 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 caused by consumers' preferences for different quality, 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.

More importantly, 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 VIIT 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 VIIT 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 two percent 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, we conclude from the indirect evidence of our empirical examination that intra-firm trade is significantly large between Japan and Korea.

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