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Vertical Intra-Industry Trade and Foreign Direct Investment between Japan and European Countries

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Abstract In this paper, we provide an overview of the development of vertical intra-industry trade (VIIT) between Japan and various European countries, including both old and new EU members, as well as emerging Central and Eastern European countries. VIIT indices constructed in this paper cover a much wider range of margins of unit price ratio than existing studies. Our empirical model attempts to explain the distributional characteristics of VIIT through foreign direct investments (FDI), in addition to traditional determinants of IIT, such as differences in GDP per capita, average GDP, and smaller and larger GDPs. Our sample covers the period from 1988 to 2004 for bilateral trade between Japan and 31 European countries. Our econometric methodology for these panel data uses fixed-effect model estimation with a variable transformation determined by a Box-Cox approach. We find that intra-industry trade between European countries and Japan increases with their corresponding Japanese FDIs, especially for new EU member countries. Our results also indicate that it is important to measure a wider range of quality based on relative prices rather than the traditional ratio used in the literature.

Keywords Foreign direct investments · Fragmentation · Japan-Europe · Quality · Vertical intra-industry trade

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Introduction

The formation of stronger economic ties between European countries due to the creation and expansion of the EU contributed to an increase in intra-industry trade (IIT) among European countries (Fontagné et al., 2006)[1]. The emerging economies in Central and Eastern Europe also reoriented their trades from within former bloc states to the EU member countries, and the share of IIT with the EU also increased (Hoekman and Djankov, 1996). The importance of bilateral trade flows within industries for European countries extends even with respect to non-European countries, including Japan. Given the extensive degree of Japanese foreign direct investments (FDI) and exports to Europe, it is worthwhile to solely focus on IIT between Japan and European countries. In this paper, we investigate vertical intra-industry trade between Japan and European countries, including both old and new EU members, as well as emerging Central and Eastern European countries.

For theoretical models with differentiated products (Helpman and Krugman, 1985), intra-industry trade increases with an increase in the similarity of endowments of two economies, resulting in more horizontal IIT (HIIT, differentiated products of same quality). On the other hand, a country may export a product whose quality is different from its corresponding import, as in the North-South trade model of Flam and Helpman (1987) and Falvey and Kierzkowski (1987). In both models, demands for different quality products are driven by heterogeneity in consumers' income. These models suggest that vertical IIT (VIIT), with price ratios of export to import deviating substantially from unity, is more likely to be observed between countries with different incomes. We expect to find this VIIT between Japan and less-developed European countries while HIIT is likely to be observed between Japan and more advanced old EU countries.

Additionally, emerging economies in Eastern Europe provide opportunities for foreign direct investments, resulting in an increasing parts and components trade between subsidiary and parent firms, or intra-firm trade. According to a fragmentation model presented in Jones and Kierzkowski (1990), a firm can take advantage of differences in factor endowments by fragmenting the production process across regions where intensively used factors may be more productive or available at lower costs. In a two country framework, a fragmented production process (which occurs somewhere in the middle of the entire production process) in a foreign country requires inputs from the home country and the ability to ship outputs back to the home country[2], resulting in increased VIIT. (Markusen and Maskus 2002) provide a unified treatment of FDI and intra-industry trade with multinational firms. Their model indicates that VIIT may increase with FDI between

[1] Fontagné et al. (2006) found that IIT was the highest between Germany and France among possible pairs of countries in the world in 2000.

[2] Fragmentation is not always necessary to increase IIT if the fragmented part of production is at either end of the entire process (leading to one-way trade) or if more than two countries are involved. Also, fragmentation does not need to be conducted via FDI; it can be implemented by outsourcing production to existing local firms.

emerging European countries and Japan. At this point, it is important to make a clear distinction between the two driving forces of VIIT. We define the first case, in which consumers demand for different quality of products (Flam and Helpman 1987; Falvey and Kierzkowski 1987), as quality-based VIIT and the second case, in which multinationals fragment productions across regions via FDI (Markusen and Maskus 2002), as FDI-based VIIT[3].

For the measurement of vertical intra-industry trade, the threshold values of 15% and 25% differences in the relative price of exports and imports are used extensively to disentangle vertical IIT from horizontal IIT[4] in the previous empirical studies. Although this strategy can successfully differentiate HIIT from VIIT, VIIT measured at these magnitudes of price differences embraces both quality-based and FDI-based VIIT. Price differentials between export prices and import prices are likely to be wider for FDI-based VIIT (i.e., intra-firm trade) because typical intra-firm trade involves parts and components going in one direction and finished or assembled products going in the opposite direction.

For the above reasons, we construct VIIT to include a much wider range of margins of unit price ratios than the range of 15 and 25% margins used in the existing studies. Our empirical model attempts to explain the distributional characteristics of VIIT through foreign direct investments, in addition to traditional determinants of IIT such as differences in GDP per capita, average GDPs, and both smaller and larger GDPs.

Our sample covers the period from 1988 to 2004 for bilateral trade between Japan and 31 European countries (six emerging countries are included only after 1993). Our econometric methodology for these panel data uses fixed-effect model estimation with a variable transformation determined by a Box-Cox approach. Empirical results reveal that the effect of economic size variables is different between older EU members and newer EU members. We also find that intra-industry trade between European countries and Japan increases with their corresponding Japanese FDIs, especially for new EU member countries. This empirical result is consistent with our hypothesis that the recent rise in VIIT in emerging economies in Europe is partly driven by fragmentation of production via Japanese FDIs. Our results also indicate that it is important to measure a wider quality range based on relative prices, rather than the traditional margins of 15% and 25% used in the literature.

The paper proceeds as follows. In the next section, we briefly review the literature on the determinants of intra-industry trade, focusing especially on the effect of FDI on vertical intra-industry trade and summarizing different expected effects of GDP among various models. The third section contains an overview of recent developments in the Japan-Europe economic relationship. We present the preliminary evidence that a steady increase in IIT between Japan and Europe is associated with FDI. The data and empirical methodology are described in the fourth section. We implement the Box-Cox logistics transformation for dependent variables and cover the wide range of relative prices.

[3] In the following empirical section, we use the FDI variable to investigate the effect of fragmentation on VIIT. However, it is important to note that fragmentation does not necessarily take a form of FDI, and only vertical FDI, not horizontal FDI, involves international fragmentation of production.

[4] To the best of our knowledge, all studies investigating VIIT use only these values (e.g., Greenaway et al. (1994) and Fukao et al (2003)).

Empirical results are presented in the fifth section. In the final section, we discuss these results and conclude.

Foreign Direct Investment and the Determinants of Vertical Intra-Industry Trade

The pioneering works for VIIT models are Falvey and Kierzkowski (1987) and Flam and Helpman (1987). Falvey and Kierzkowski (1987) modify traditional Heckscher-Ohlin trade models with quality differentiated products. Vertical product differentiation means that different varieties are of different qualities and that consumers are assumed to rank alternative varieties according to product quality. In these models, wider income differences reduce the volume of intra-industry trade and the range of trade. On the other hand, the framework of the Flam and Helpman (1987) model with Recardian technological differences also considers quality differentiation; however, a large difference in income levels increases the share of VIIT, as income differences generate dissimilarity in demand. The model of Falvey and Kierzkowski (1987) generates the following country-specific hypothesis: VIIT will be greater if (1) the difference in factor endowments between countries is larger, (2) the difference in country size is smaller, and (3) the sum of the two countries size is larger. However, Flam and Helpman (1987) would suggest otherwise.[5]

The product cycle theory developed by Vernon (1966) divides the life cycle of new products into three stages: new product stage, maturing product stage, and standardized product stage. In the final product stage, FDI allows less-developed countries to export standardized low-quality differentiated products to developed countries while importing new high-quality product varieties from these countries at the same time. Thus, Vernon's theory suggests a positive relationship between VIIT and per-capita income differences, as well as between VIIT and FDI. (Markusen and Maskus 2002) explicitly incorporate the role of multinational firms in a two-country, two-good, two-factor general-equilibrium model, extending the models in Markusen and Venables (1998, 2000). Their simulated results suggest that intra-industry trade becomes greater between countries with dissimilar factor endowments, coupled with more foreign direct investments after a decline in trade cost and investment cost in host countries[6]. This decline in costs leads to a positive correlation between FDI and VIIT.

Fragmentation theory in Jones and Kierzkowski (1990) suggests that the multiple stages of a good's production take place across two or more countries as service cost declines. Cheng et al. (2001) explicitly link foreign direct investments to international fragmentation in their model, and Jones et al. (2002) claim that fragmentation raises the degree of intra-industry trade. Investigating parts and components trade with gravity equations, Kimura et al. (2007) find empirical evidence in support of fragmentation theory in East Asia. Fukao et al. (2003) examine the electrical machinery industry and present empirical evidence that FDI

[5] For empirical studies for VIIT, see Greenaway et al. (1994), Durkin and Krygier (2000), and Fukao et al. (2003), among others.

[6] See the Figure 11.1 and Figure 11.4 in (Markusen and Maskus 2002).

plays a significant role in the recent rapid increase in VIIT in East Asia. Türkcan and Ates (2008) focus their study on the automobile parts and components sector of the US and find a positive effect of FDI on VIIT. In summary, there is much empirical evidence to suggest a positive effect of FDI on VIIT. However, there is no single study directly testing the effect of FDI on VIIT for all industries between Japan and Europe. Our study attempts to fill this gap.

The Development of Japan-Europe Trade over the Last Two Decades

In this section, we present an overview of recent developments in the total trade, foreign direct investment and intra-industry trade relationship between Japan and Europe. Japan's total trade increased twofold over the 18 years between 1988 and 2005. In terms of share, however, both the US and Europe lost share due to a sharp rise in total trade with China (i.e. an eightfold increase over the period). Within European countries, new EU members gained a higher share, although only by a small amount, while old EU members lost trade share with Japan by about six percentage points. Non-members of the EU demonstrated a slight decline in share in our sample. Among those experiencing a share increase in total trade with Japan were Ireland (0.25 percentage point increase), Hungary (0.16), Czech Republic (0.16), Spain (0.08), Turkey (0.06), Netherlands (0.04), Norway (0.03), Poland (0.03), Slovakia (0.03), Estonia (0.03), Luxemburg (0.01), Malta (0.01), Latvia (0.01), and Lithuania (0.01).

Table 1 shows Japanese FDI in European countries between 1988 and 2003 in terms of the number of newly established subsidiaries. From this table, we observe two distinguishing features of Japanese foreign direct investment in European countries. First, there are continuous FDI inflows to a subgroup of old EU members, namely, Belgium, France, Germany, Italy, Netherlands, Spain, and the UK. In the case of the UK, which is the largest recipient of Japanese FDI, there were already over 200 Japanese subsidiaries prior to 1987, and the UK continued to receive about 28 new establishments per year, on average. Second, we observe a rapid increase in FDI flows to some emerging European economies in recent years. For the Czech Republic, Hungary, Poland, and Russia, there was no establishment of Japanese subsidiaries prior to 1987. In the most recent years from 1992, however, Japanese FDI inflows to these countries exceeded inflows to the older EU members not mentioned above.

Given these trade and FDI developments between European countries and Japan, we ask to what degree intra-industry trade is important for overall trade. Grubel and Lloyd (1975) define IIT for industry k between country i and j as the difference between the industry's trade balance and the total trade of industry. In order to make the index comparable across industries and countries, the index is normalized by total industry trade.

$$IIT_{ij} = \frac{\sum_k IIT_{ijk}}{\sum_k \left(X_{ijk} + M_{ijk}\right)} = \frac{\sum_k \left(\left(X_{ijk} + M_{ijk}\right) - \left|X_{ijk} - M_{ijk}\right|\right)}{\sum_k \left(X_{ijk} + M_{ijk}\right)} \quad (1)$$

Table 1 Japanese FDI into European countries

	pre-1987	1988–1995	1996–2003		pre-1987	1988–1995	1996–2003
Austria	19	12	9	Bulgaria	1	1	0
Belgium	58	33	33	Czech	0	18	36
Denmark	9	7	8	Estonia	0	1	2
France	100	109	92	Finland	5	4	5
Germany	220	185	134	Hungary	0	19	28
Greece	6	2	3	Latvia	0	0	1
Ireland	5	17	15	Poland	0	18	36
Italy	45	57	43	Romania	0	1	8
Luxembourg	5	8	1	Russia	0	19	19
Netherlands	91	132	93	Slovakia	0	3	9
Norway	7	3	4	Slovenia	0	1	3
Portugal	7	10	7	Switzerlan	22	12	12
Spain	32	52	33	Turkey	2	11	10
Sweden	18	14	19				
UK	221	243	213				

The figures in the first column show the accumulated number of overseas establishments by Japanese parent corporations. Figures in other columns are the number of newly established overseas subsidiaries during the period. (Source: author's calculation based on the Overseas Japanese Corporations, 2005)

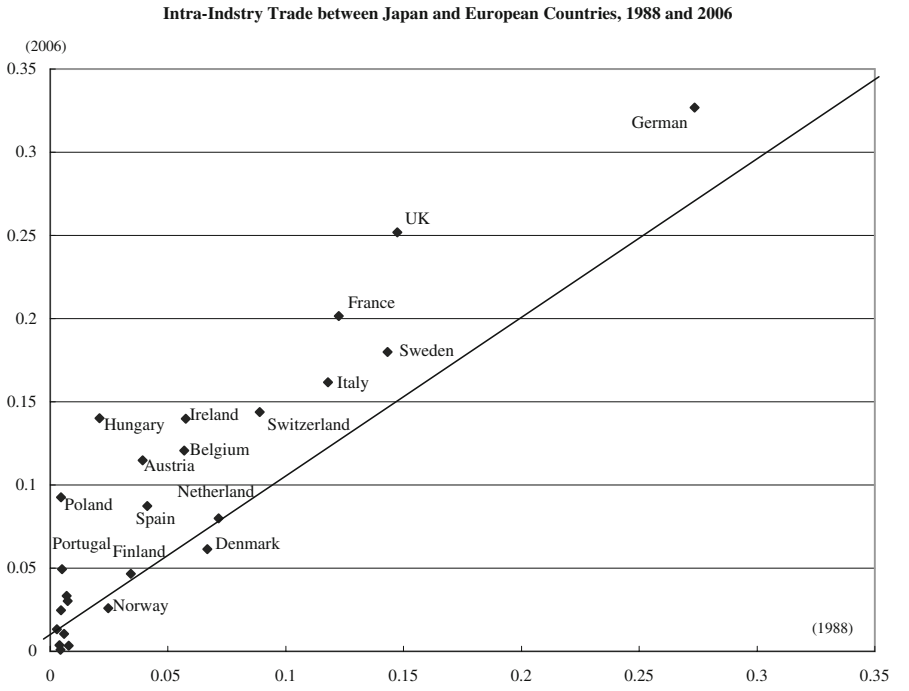
To measure the overall extent of IIT in total bilateral trade, the industry indices are summed over all industries. The index in (1) is equal to 1 if all trade is intra-industry trade and 0 if all trade is inter-industry trade.

In Fig. 1, we plot the Grubel-Lloyd index for each European country with respect to Japan for 1988 and 2006. The diagonal is a 45 degree line. Any countries above the diagonal line experienced an increase in intra-industry trade with Japan during this period, while any countries below the diagonal experienced a decline.

We note that a country located at a further distance from the origin in Fig. 1 is associated with a higher intra-industry trade. We also observe that the five largest intra-industry trade countries consist of only old EU members: Germany, UK, France, Sweden, and Italy. This preliminary survey of IIT seems to support the view of Helpman and Krugman (1985) that similar countries trade more within industries. We should note that these countries also appear in Table 2 as the largest recipients of Japanese FDI. Casual observation seems to support the positive relationship between intra-industry trade and foreign direct investments.

In addition, a country located further above the diagonal line experienced a rapid increase in intra-industry trade over the period. For this measure, we observe that some European emerging economies experienced large increases in intra-industry trade with Japan, especially Hungary and Poland. It is noteworthy that these two countries also hosted a large number of Japanese foreign direct investments in recent years. The view of (Markusen and Maskus 2002) seems to hold for these countries.

In the following sections, we formally investigate the determinants of VIIT between Japan and European countries by utilizing a panel regression analysis, especially focusing on the role of Japanese foreign direct investments in partner countries.



Note: International trade data are taken from the Japan Custom, Ministry of Finance. We aggregated the values of the original 9-digit trade codes into an HS 6-digit classification, with the unit price at HS 6-digits calculated using the weights of trade values at the 9-digit level.

Fig. 1 Intra-Indstry Trade between Japan and European Countries, 1988 and 2006

Data and Empirical Methods

HIIT, VIIT, and Relative-Price Based Index of VIIT

To determine horizontal and vertical intra-industry trade, we use the indices and methodology of Greenaway et al. (1994) and (Fontagné and Freudenberg 1997). The ratio of export to import unit values, p_{ijk}, is used to distinguish HITT from VIIT. We divide the entire set of industries, K, into three subsets: $K_H(\alpha)$, the set of industries with $p_{ijk} \in [1/(1+\alpha), 1+\alpha]$, $K_V^H(\alpha)$, the set of higher-price exporting industries with $p_{ijk} > 1+\alpha$, and $K_V^L(\alpha)$, the set of lower-price exporting industries with $p_{ijk} < 1/(1+\alpha)$[7].

If the relative price of export products to import products is equal to or greater than $(1+\alpha)$, we call this higher-price VIIT, $\text{VIIT}^{\text{H}}(\alpha)$, as in Eq. 2. For $\text{VIIT}^{\text{L}}(\alpha)$, the relative price of export products to import products must be equal to or less than $1/(1+\alpha)$ to be included in this index, and we call this lower-price VIIT as defined in Eq. 3.[higher-price VIIT (for $p_{ijk}>1+\alpha>1$); lower-price VIIT (for $p_{ijk}<1/(1+\alpha)<1$)]

[7] Many researchers use $1-\alpha$ for the lower bound. However, this measure is not symmetric for obvious reasons. Instead, we prefer to use the symmetric measure presented in (Fontagné and Freudenberg 1997).

Table 2 VIIT between Japan and Old EU members (+2)

	VIIT(0.25)	VIIT(0.50)	VIIT(0.67)	VIIT(0.80)	GL Index	VIIT(1.25)	VIIT(1.50)	VIIT(2.00)	VIIT(4.00)
Log of max of GDPs:	0.3157*	0.1356	0.3572	0.2268	0.4731***	0.0670	0.0537	−0.0210	0.1062
LGDP_MAX	(0.1712)	(0.3149)	(0.2813)	(0.4241)	(0.1780)	(0.1493)	(0.1838)	(0.1314)	(0.0900)
Log of min of GDPs:	0.0549**	0.0560**	0.0667**	0.0535**	0.0377*	0.0047	0.0026	−0.0058	0.0097*
LGDP_MIN	(0.0278)	(0.0260)	(0.0281)	(0.0258)	(0.0228)	(0.0078)	(0.0076)	(0.0056)	(0.0052)
Average of GDPs:	−0.3768*	−0.1942	−0.4076	−0.2503	−0.4044**	−0.0177	−0.0102	0.0618	−0.1025
LGDP_AVE	(0.1998)	(0.3437)	(0.3124)	(0.4611)	(0.1994)	(0.1601)	(0.1954)	(0.1392)	(0.0955)
Log of absolute difference of par capita	−0.0026	0.0015	0.0016	0.0014	0.0002	−0.0004	0.0000	−0.0003	−0.0009**
LD_PCGDP	(0.0018)	(0.0030)	(0.0027)	(0.0030)	(0.0027)	(0.0009)	(0.0007)	(0.0006)	(0.0004)
Accumulated JPN subsidiaries	0.000075***	−0.000074	−0.000007	−0.000026	0.000185***	0.000114*	0.000105*	0.000085**	0.000073***
JPNFDI	(0.000019)	(0.000204)	(0.000124)	(0.000144)	(0.000062)	(0.000060)	(0.000055)	(0.000039)	(0.000021)
Observations	289	289	289	289	289	289	289	289	289
No. of countries	17	17	17	17	17	17	17	17	17
adj. R2	0.76	0.71	0.88	0.88	0.95	0.82	0.80	0.80	0.64

The dependent variable is Box-Cox logistics (with lamda=1) of Grubel-Lloyd (GL) index and VIIT(p) index where p indicates the threshold level of relative price of export to import. When p is less (greater) than 1, only products of which relative price is lees (greater) or equal to p are summed in VIIT index. Figures in parenthesis are standard errors (heteroskedasticy consistent for fixed-effect model.) The statistical significance of one, five and ten percent are denoted by "***","**","*", respectively

$$VIIT^{H}(\alpha) = \sum_{k \in K_V^H(\alpha)} IIT_{ijk} \Big/ \sum_{k \in K} \left(X_{ijk} + M_{ijk}\right) \tag{2}$$

$$VIIT^{L}(\alpha) = \sum_{k \in K_V^L(\alpha)} IIT_{ijk} \Big/ \sum_{k \in K} \left(X_{ijk} + M_{ijk}\right) \tag{3}$$

The relative unit value for each component of IIT is calculated at the Harmonized System 6-digit level in order to be classified as either higher-price or lower-price VIIT. In order to capture wider relative price differences among European countries, we use margin values, α, of 0.05, 0.15, 0.25, 0.35, 0.5, 1, 2, and 3, while existing studies only use margins up to 0.25.[8] For the sake of clear exposition, we use the relative price, p, instead of the margin, α, to indicate the threshold value for defining vertical intra-industry trade, as in Eq. 4:

$$VIIT(p) = \begin{matrix} VIIT^{H}(\alpha) & if\ p = 1+\alpha > 1 \\ VIIT^{L}(\alpha) & if\ p = \frac{1}{1+\alpha} < 1 \end{matrix} \tag{4}$$

Estimation Equations

Extending the cross-country analyses of Helpman (1987) and Hummels and Levinsohn (1995) to panel data for VIIT, we estimate the following Eq. 5.

$$VIIT(p)_{jt} = \lambda_j + \beta_1 LGDP\_MAX_{jt} + \beta_2 LGDP\_MIN_{jt} + \beta_3 LGDP\_AVE_{jt} + \beta_4 LD\_PCGDP_{jt} + \beta_5 JPNFDI_{jt} + \varepsilon_{jt} \tag{5}$$

Explanatory variables in Eq. 5 are:

- LD_PCGDP is the natural logarithm of the absolute difference in GDP per capita (PPP, in constant 2005 international dollars) between Japan and each European trading partner.

$$LD\_PCGDP_{jt} = ln\left|PCGDP_{jt} - PCGDP_{JPN,t}\right|$$

Falvey and Kierzkowski (1987) suggest that this relationship will be positive for the VIIT model, while Flam and Helpman (1987) and Markusen and Maskus (2002) predict a negative sign for this variable. Helpman and Krugman (1985) suggest a negative relationship in the IIT model.

- LGDP_AVE is the natural logarithm of the average GDP (PPP, in constant 2005 international dollars) of Japan and its European trading partners.

$$LGDP\_AVE_{jt} = ln\left\{\frac{1}{2}\left(GDP_{jt} + GDP_{JPN,t}\right)\right\}$$

[8] In terms of the relative price, p, of exports and imports, the values are 0.25, 0.33, 0.50, 0.57, 0.67, 0.74, 0.80, 0.87, 0.95, 1.05, 1.15, 1.25, 1.35, 1.50, 1.75, 2, 3, and 4. We only provide estimated results for 0.25, 0.5, 0.67, 0.8, 1.25, 1.50, 2, and 4 to save space.

This is a proxy for the overall economic dimension, and a positive sign is expected for both IIT and VIIT (Greenaway et al. 1994).

- LGDP_MIN and LGDP_MAX is the natural logarithm of the lower GDP and higher GDP value (PPP, in constant 2005 international dollars) between Japan and the European country.

$$LGDP\_MIN_{jt} = min\left(ln\ GDP_{jt}, ln\ GDP_{JPN,t}\right); LGDP\_MAX_{jt} = max\left(ln\ GDP_{jt}, ln\ GDP_{JPN,t}\right)$$

These variables are included to control for relative size effects. For the quality model of VIIT, we have mixed predictions: the North-South trade model of Flam and Helpman (1987) indicates a negative (positive) sign for LGDP_MIN (LGDP_MAX) while the Hechscher-Ohlin model of Falvey and Kierzkowski (1987) predicts just opposite signs for VIIT.

- JPNFDI is the accumulated number of Japanese foreign subsidiary establishments in a given European country at the end of previous year. The data are compiled from *Overseas Japanese Corporations (2005)* by Toyo Keizai, which conducts an annual survey over all the listed companies in Japan regarding their foreign subsidiaries. A positive sign is expected for VIIT between countries with different endowments in (Markusen and Maskus 2002). Jones and Kierzkowski (1990), Cheng et al. (2001), and Jones et al. (2002) also suggest a positive relationship between FDI and VIIT.

Transformation of the Dependent Variable

The Grubel-Lloyd IIT index is constructed to fall between 0 and 1. Using this index as the dependent variable in a regression violates the assumption that the error term will follow 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 (see Hummels and Levinsohn (1995)).

When the original data contain a zero value, however, the transformed value is undefined, as the logistic transformation takes a logarithmic form[9]. To get around this problem of undefined values, we use a Box-Cox transformation[10] in place of the log part of the logistic transformation with a parameter $\lambda \in (0, 1]$, following Yoshida (2008). We call the following transformation (6) the Box-Cox Logistic transformation and denote it by BCL():

$$BCL(y) = \frac{\left(\frac{y}{1-y}\right)^{\lambda} - 1}{\lambda} \lambda \in (0, 1] \tag{6}$$

[9] Researchers may inattentively classify these zero values as missing values. This will then lead to biased estimates by censoring the lowest values of the original variable and causing the sample size to be smaller.

[10] The Box-Cox transformation is a linear transformation as λ approaches 1 while it is log transformation as λ approaches 0.

We chose the parameter in the Box-Cox Logistic transformation,λ, which maximizes the log-likelihood of regression over the entire parameter values in (0,1]. The parameter values we obtained by this approach consistently indicated 1 for all ranges of relative prices[11].

Empirical Results

We divided the 31 European countries into two groups, Old EU Members+2 (Old EU, hereafter) and New EU Members+2 (New EU, hereafter). The Old EU constitutes the relatively more advanced countries, including the 15 old members of the EU and Norway and Switzerland. The New EU constitutes emerging and developing economies, including the 12 new members of the EU, as well as Russia and Turkey[12]. Tables 2 present the results for the Old EU group. In Table 2, we present the results of estimating VIIT for relatively lower price ratios of Japanese export to imports on the left-hand side and those of VIIT for relatively higher price ratios of exports to imports on the right-hand side. The results for the New EU group are presented in Tables 3, similarly.

First, the model's fitness is relatively higher for the Old EU countries, regardless of the value of p. This is a little surprising since most of the theoretical models predict that VIIT occurs between a higher income country and a lower income country. For both the Old EU and New EU countries, the adjusted R^2 is substantially higher for lower values of p; i.e., the price of Japanese exports is lower than the price of imports. For the Old EU, this result goes well with the casual observation that efficient Japanese manufacturers produce models with less expensive prices than their foreign competitors do. The higher level of the model's fitness simply reflects the fact that the case in which Japanese products are less expensive than foreign counterparts is the more dominant type of intra-industry trade between Japan and developed countries. For the New EU, however, this result does not conform to theoretical predictions of quality models, which only concern the case in which developing economies export lower-quality (price) products. We need to refer to the concept of fragmentation theories to interpret our results. If components, including high technology parts of engines, integrated circuits, and solar cells, are produced in Japan, exported to emerging economies, and then assembled (which is the less technology-intensive part of production) in emerging economies in Europe to be re-exported back to Japan, then the relative price of Japanese exports should be less than one.

Second, the coefficients for GDP of the smaller size economy, *LGDP_MIN*, are positive and statistically significant for the Old EU in Table 2 (for the relatively lower price of Japanese exports). The expected negative sign for *LGDP_MIN* in a quality model of Flam and Helpman (1987) does not match with the empirical results for

[11] In a previous version of this paper, we chose λ to be 0.1 (close to zero) for the Box-Cox part of the transformation to take on a quasi-logarithmic form. However, the maximum likelihood method indicated the other extreme: a linear transformation for the Box-Cox part. We thank an anonymous referee for pointing out the weakness of our previous approach.

[12] We also conducted panel regressions including all 31 European countries; however, stark differences in estimated coefficients between the two groups support our approach to not pool all of the countries together. The regression result of the pooled groups can be obtained from the authors upon request.

Table 3 VIIT between Japan and New EU members (+2)

	VIIT(0.25)	VIIT(0.50)	VIIT(0.67)	VIIT(0.80)	GL Index	VIIT(1.25)	VIIT(1.50)	VIIT(2.00)	VIIT(4.00)
Log of max of GDPs:	−0.0614*	−0.0918**	−0.1380***	−0.1453***	−0.1432***	−0.0128	−0.0086	−0.0061	0.0023
LGDP_MAX	(0.0366)	(0.0360)	(0.0402)	(0.0407)	(0.0404)	(0.0183)	(0.0183)	(0.0191)	(0.0184)
Log of min of GDPs:	0.0134	0.0104	0.0054	0.0054	0.0076	0.0024	0.0031	0.0042	0.0039
LGDP_MIN	(0.0116)	(0.0135)	(0.0163)	(0.0172)	(0.0182)	(0.0062)	(0.0061)	(0.0060)	(0.0056)
Average of GDPs:	0.0323*	0.0655***	0.1165***	0.1251***	0.1352***	0.0216	0.0158	0.0113	0.0032
LGDP_AVE	(0.0184)	(0.0210)	(0.0255)	(0.0251)	(0.0280)	(0.0171)	(0.0170)	(0.0176)	(0.0180)
Log of absolute difference of par capita	0.0210	0.0134	0.0053	0.0059	0.0031	−0.0031	−0.0028	−0.0015	0.0003
LD_PCGDP	(0.0219)	(0.0227)	(0.0269)	(0.0284)	(0.0276)	(0.0059)	(0.0057)	(0.0051)	(0.0033)
Accumulated JPN subsidiaries	0.000232***	0.000570***	0.000973***	0.001031***	0.001388***	0.000302***	0.000279***	0.000197***	0.000088
JPNFDI	(0.000062)	(0.000140)	(0.000228)	(0.000236)	(0.000231)	(0.000086)	(0.000080)	(0.000073)	(0.000056)
Observations	212	212	212	212	212	212	212	212	212
No. of countries	14	14	14	14	14	14	14	14	14
adj. R2	0.35	0.55	0.62	0.64	0.68	0.38	0.37	0.32	0.26

The dependent variable is Box-Cox logistics (with lamda=1) of Grubel-Lloyd (GL) index and VIIT(p) index where p indicates the threshold level of relative price of export to import. When p is less (greater) than 1, only products of which relative price is lees (greater) or equal to p are summed in VIIT index. Figures in parenthesis are standard errors (heteroskedasticy consistent for fixed-effect model.) The statistical significance of one, five and ten percent are denoted by "***","**","*", respectively

VIITs, while the positive sign is consistent with horizontal intra-industry trade in the model of Helpman (1987). This result is not surprising because the assumption of the North-South trade model of Flam and Helpman (1987), where the income gap between two countries is assumed to be large, does not match for intra-industry trade between Japan and developed EU countries. One possible explanation for this is that price differentials at these degrees in VIITs still capture horizontal intra-industry trade between developed countries. This positive sign for *LGDP_MIN* only reinforces, for example, the casual observation in automobile industries in which a relatively wide range of prices can be found for the HS6 (8703.23) category: automobiles with a reciprocating piston engine displacing between 1500 cc to 3000 cc.

On the other hand, for intra-industry trade between Japan and New EU for the lower price of Japanese exports in Table 3, both signs of *LGDP_MAX* and *LGDP_MIN* are consistent with the multinational model of (Markusen and Maskus 2002), but they are inconsistent with the quality model of Flam and Helpman (1987). Even after taking account of half the coefficients of LGDP_AVE, the signs are still consistent with (Markusen and Maskus, 2002).[13]

Third, the effect of FDI on intra-industry trade is substantial for both Old EU and New EU. However, the FDI effect is asymmetric between lower and higher relative price of Japanese exports for Old EU, while FDI raises intra-industry trade for New EU regardless of relative prices. For a higher relative price of Japanese exports, the accumulated numbers of Japanese subsidiaries in developed European countries raise intra-industry trade, although the impact diminishes as price margin widens. On the other hand, for a lower relative price of Japanese exports, the coefficients are not statistically significant for most of the relative price range.[14]

For New EU countries, the presence of Japanese subsidiaries raises VIIT regardless of relative prices. By comparing the magnitudes of coefficients, the impact is greater for a lower relative price of Japanese exports than a higher relative price in Table 3. This result can be interpreted to mean that Japanese FDI in New EU countries is more strongly associated with the fragmentation of processes in which Japan exports capital-intensive components. New EU countries, using these imported components, assemble the final products (or semi-components) and ship them to Japan.

The impact of FDI on VIIT is greater for the New EU group. For example, the estimated coefficient for the 25% margin is 0.000302 for New EU but only 0.000114 for *Old EU*. In general, the impact is greater for the New EU group for other margins that have estimated coefficients with a magnitude about twice that of the Old EU.

Discussion and Conclusion

In this paper, we provide an overview of the development of intra-industry (IIT) trade in Japan with respect to various European countries, including both old and new EU members as well as emerging Eastern European countries. For the measurement of intra-industry trade, we construct vertical intra-industry trade (VIIT) measures at much wider margins of unit price ratios than existing studies, in addition

[13] The net effects of *LGDP_MAX* variable and *LGDP_MIN* are $\beta_1+0.5\beta_3$ and $\beta_2+0.5\beta_3$, respectively.
[14] It is noteworthy, however, that FDI still promotes IIT only for extreme values of lower relative price.

to a Grubel-Lloyd index. Our empirical model attempts to explain the distributional characteristics of VIIT through foreign direct investments in addition to traditional determinants of VIIT.

Our sample covers the time period of 1988 to 2004 for bilateral trade between Japan and 31 European countries. For our econometric methodology with panel data, we use fixed-effects estimation with Box-Cox transformed dependent variables.

Our empirical evidence points out three noteworthy findings that need to be expressed in detail. First, intra-industry trade between Japan and Old EU countries is horizontal in nature, even for the empirical definition for VIIT, with relative price deviating substantially from unity. In addition, the traditional determinants of VIIT are of no help in explaining higher Japanese exports price for the Old EU group. We conclude that Japan and Old EU countries engage largely in horizontal intra-industry trade but with much wider price differentials than previously defined in empirical works. Secondly, intra-industry trade between Japan and New EU countries is more consistent with the multinational corporation model of (Markusen and Maskus 2002) and fragmentation theory of Jones and Kierzkowski (1990) (i.e. FDI-based VIIT) but not with the North-South quality model of Flam and Helpman (1987). Thirdly, Japanese foreign direct investments in New EU countries play a significant role in carrying out internationally fragmented production and therefore lead to an increase in VIIT.

The other finding is that, at extreme values of relative prices (i.e., p=4.00 for Old EU), the estimated coefficients are statistically significant, even when the estimated coefficients for mid-range relative prices are not statistically significant. This result calls for further investigation; however, this is a good example of a situation in which VIITs defined by different ranges of relative prices demonstrate quite distinct responses to a specific set of economic variables. It is important to note that previous studies' definitions of the VIIT index with traditional ranges of relative prices may have missed distinctly different VIIT behavior at large margins. Our results indicate that it is important to measure a wider quality range based on relative prices rather than just relying on the traditional ratios used in the literature.

Some caveats need to be stated. First, foreign direct investments can take a more complicated form involving more than just two countries, as in the export-platform FDI model (Motta and Norman 1996; Ekholm et al., 2003) and the complex FDI model in Yeaple (2003). In these cases, it is not straightforward to conclude a positive relationship between FDI and intra-industry trade. However, our empirical results are able to capture the positive association of FDI with IIT, without referring to particular FDI types considered in various theoretical models.

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