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Vertical intra-industry trade and product quality: the case of South Korea, 1996–2003

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Abstract

This paper contributes to empirical research of intra-industry trade, especially vertical intra-industry trade (VIIT), by two aspects. Firstly, we separate VIIT into higher-export-price VIIT and lower-export-price VIIT. Secondly, we give attention to R&D and FDI stock in explaining VIIT determinants. Applied to panel data representing South Korea's bilateral trade with 15 OECD countries and Taiwan from 1996 through 2003, this alternative makes an intricate understanding of the VIIT determinants possible. Main empirical findings are that South Korea's R&D investments focus on price competitiveness while its inward FDI seeks efficiency and its outward FDI seeks a market in this period.

Keywords: intra-industry trade (IIT), vertical differentiation, R&D stock, FDI, panel data
JEL Classification Codes: C23, F1, O30

1. Introduction

In international trade, the simultaneous export and import of products belonging to the same industry is known as intra-industry trade (IIT). Tracing the milestones of IIT study, perhaps the most essential advance has been the decomposition of IIT into horizontal IIT (HIIT) and

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vertical IIT (VIIT). This classification is based on product differentiation. HIIT is characterized by trade in products that are close substitutes for one another but differ in characteristics; VIIT on the other hand consists of trade in products that differ in quality level (Greenaway and Torstensson, 1997). The predominance of VIIT in IIT is well known (Fontagné et al., 2006).

In the empirical literature, the HIIT/VIIT distinction is accomplished by a unit value (UV) comparison. If the relative UV, defined as the ratio of the product's export UV to its import UV, is within a specific dispersion range $(1\pm\alpha)$, trade in that product is classified as HIIT, and if it is out of that range the trade is classified as VIIT. An aggregation problem arises with this categorization method for VIIT, whereby cases where the export UV is both higher and lower than the import UV are assigned to the same category. This calls for a further separation of VIIT into higher-export-price VIIT (HEP-VIIT) and lower-export-price VIIT (LEP-VIIT). We expect that such a division will shed more light on IIT's intricacies, just as the distinction between HIIT and VIIT helped to overcome inconsistent empirical results in the early 1990s. To the best of our knowledge, Greenaway et al. (1994) were the first to propose the decomposed VIIT analysis. However, because no difference between the types of analysis was found, the new method of categorization has not been paid much attention.

Research on the determinants of IIT constitutes another major advance in IIT studies. Researchers have studied various country- and industry-specific determinants, recognizing differences in factor endowments and market size, physical and/or institutional barriers to trade, and foreign direct investment (FDI) as the key elements determining the nature of IIT at the country level. Because we are focusing only on the country level, we did not list industry-specific determinants. Such national factors have been commonly proxied by GDP per capita, GDP, distance and tariff rate, FDI amounts, and sales ratio of multinational enterprise, respectively. Although such determinants have been studied for decades, little is known about the impact of technological capacity on IIT. Considering the growing importance of research and development (R&D) in the manufacturing sector and the fact that VIIT is a distinction born from product differentiation according to quality, this is very surprising. As for FDI, little is known of its role in the Asian countries' VIIT.

Many empirical studies on IIT have been done. Recently, Turkcan and Ates (2011) studied VIIT in Auto-parts industry in empirical perspectives and paper of Sawyera et al (2010) is also notable. However, in many cases, these papers are either about specific industry without consideration of technological capacity difference or aggregated analysis of IIT without distinguishment between the HIIT and VIIT.

Given these perspectives, this paper investigates the determinants of South Korea's VIIT with special emphasises on national R&D and FDI. Separate investigations of HEP-VIIT and LEP-VIIT follow a description of South Korea's IIT and an analysis of aggregated VIIT.

2. Analysis

IIT calculation and descriptive analysis

We calculated a bilateral IIT index for trade between South Korea and 16 countries between 1996 and 2003 based on the six-digit nomenclature of the Harmonized Commodity Description and Coding System (HS) 1996 statistics. This time period covers the S.Korean financial crisis and recovery. To confine this study to the manufacturing sector, product groups that have a two-digit HS code prior to 28 are excluded from analysis. The data source is International Trade by Commodity Statistics, a database of international trade statistics published by the Organisation for Economic Co-operation and Development (OECD). The 16 countries are the 15 OECD countries of Austria, Belgium, Canada, Finland, France, Germany, Ireland, Italy, Japan, Mexico, Netherlands, Portugal, Spain, the United Kingdom, and the United States and Taiwan, which is included because of its importance in South Korean trade and data accessibility.[1] The decomposition of IIT into HIIT and HEP- and LEP-VIIT employing a 25% unit value dispersion cut-off range is followed by an unadjusted Grubel and Lloyd index (GL index) calculation.[2]

$$\text{HIIT}: \ 1-\alpha \le \frac{UV_i^{\exp}}{UV_i^{imp}} \le 1+\alpha$$

$$\text{VIIT : LEP-VIIT}: \ \frac{UV_i^{\exp}}{UV_i^{imp}} < 1-\alpha \quad \text{and} \quad \text{HEP-VIIT}: \ 1+\alpha < \frac{UV_i^{\exp}}{UV_i^{imp}} \qquad (1)$$

$$\text{GL index of IIT} = \frac{\sum (X_i^p + M_i^p) - \sum \left| X_i^p - M_i^p \right|}{\sum (X_i + M_i)} = \frac{2 \times \min(X_i^p, M_i^p)}{\sum (X_i + M_i)}$$

where $UV_i^{\exp}$ and UV_i^{imp} are the export and the import unit value of product *i*, respectively ; X_i and M_i are the export and the import value of product *i*, respectively ; p denotes product differentiation type ; and $\alpha = 0.25$.

Table 1 shows that IIT constitutes around 30% of the total trade between South Korea and the 16 countries for the period 1996–2003 and that VIIT is the dominant category of IIT. Looking at LEP versus HEP, more than 80% of South Korea's VIIT is LEP-VIIT. That means

[1] According to the Korea National Statistics Office, Taiwan ranked sixth in South Korea's total trade volume for the period 1996–2004.

[2] 15% and 25% are the common cut-off values addressed (Greenaway et al., 1994). For the sake of measuring differences in unit value (free on board for exports; cost, insurance, and freight for imports), 25% dispersion is adopted.

that South Korea's position in a North-South trade model is "South." Such positioning is relative, because if the trading partners are not confined to OECD countries, it will change.

Table 1. South Korea's intra-industry trade with 15 OECD countries and Taiwan, 1996–2003

	1996	1997	1998	1999	2000	2001	2002	2003	Volume Weighted Average
GL index (%, over total trade)									
IIT	28.1	35.1	37.3	36.1	35.6	32.8	32.4	32.2	33.6
HIIT	4.0	3.8	4.9	5.5	6.2	6.3	8.7	10.3	6.4
VIIT	24.1	31.3	32.4	30.6	29.5	26.5	23.7	21.9	27.2
Decomposition of VIIT (%, over total VIIT)									
HEP-VIIT	21.7	16.4	14.8	19.3	24.6	12.6	13.5	13.4	17.3
LEP-VIIT	78.3	83.6	85.2	80.7	75.4	87.4	86.5	86.6	82.7

Determinants of VIIT

According to Falvey and Kierzkowski (1987), higher-income countries, with a higher capital-to-labour ratio, will specialize in the manufacture of relatively high-quality products, and vice versa. Greenaway et al. (1994) used differences in per capita income as a proxy for differences in physical factor endowment. We use the difference in gross domestic product (GDP) per capita between South Korea and the trading partner country to capture the impact of physical factor endowment (*DGDPPC*).

Flam and Helpman (1987) constructed a model that emphasizes the impact of a southern country's technological progress on North-South trade. We use absolute differences in R&D stock per worker as a representation of technological factor endowment differences (*DRNDs*).

Helpman and Krugman (1985) related relative economy size and IIT. They argued that the smaller the difference in economic size between trading countries, the higher the expected IIT. We use difference in GDP (*DGDP*) as an indicator of market size difference. Geographical distance has been recognized as an important factor in reducing IIT. We calculate the logarithm of the nautical distance from the trading partner country's capital to Seoul (*Distance*).

It is well known that trade imbalances affect their IIT index. The index of South Korea's trade imbalance (*TI*) with its trading partner is defined by the absolute difference between the manufacturing sector's export volume to and its import volume from the trading partner country divided by total trade volume.

As Zhang and Zhou (2005) point out, FDI could enlarge IIT over total trade volume and could be substitute for IIT. Zhang and Zhou (2005) term the former *efficiency-seeking* FDI and the latter *market-seeking* FDI. Inward FDI stock (*InFDIs*) from the trading partner country and outward FDI stock (*OutFDIs*) from South Korea to the trading partner country are incorporated in our models.

Since the prominent paper of Coe and Helpman (1995), which addressed R&D spillover among trading partners, researchers have become increasingly aware that FDI is one of the main channels for international R&D spillover. Therefore an interaction term between FDI and national R&D stock is incorporated in the estimation model. The following equation provides the model for the VIIT analysis. The data sources and detailed definitions of variables are given in Appendix.

Model A

$$\begin{aligned} VIIT_{it} &= \beta_0 + \beta_1 DGDPPC_{it} + \beta_2 DRNDs_{it} + \beta_3 DGDP_{it} + \beta_4 Distance_{it} \\ &+ \beta_5 TI_{it} + \beta_6 InFDIs_{it} + \beta_7 OutFDIs_{it} \\ &+ \beta_8 DRNDs_{it} \times InFDIs_{it} + \beta_9 DRNDs_{it} \times OutFDIs_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

where i = Korea's trading partner countries (16 countries) and t = year (1996–2003).

Based on the rationale for the determinants in setting up model A, we expect the signs of β_1 and β_2 to be positive, β_3, β_4, and β_5 to be negative, and β_6, β_7, β_8, and β_9 to be ambiguous.

The next step is to decompose VIIT into LEP-VIIT and HEP-VIIT. With these specifications, we have the explained variables, which have a relative position in the VIIT classification. Therefore we change the explanatory variables; *DGDPPC*, *DRNDs*, and *DGDP* which stand for the absolute difference to relative value of South Korea. GDP per capita ratio (*GDPPCR*), for example, is defined by GDP per capita of South Korea over GDP per capita of the trading partner country (see Appendix).

Model B

$$\begin{aligned} H(L)EPVIIT_{it} &= \beta_0 + \beta_1 GDPPCR_{it} + \beta_2 RNDsR_{it} + \beta_3 GDPR_{it} + \beta_4 Distance_{it} \\ &+ \beta_5 TI_{it} + \beta_6 InFDIs_{it} + \beta_7 OutFDIs_{it} \\ &+ \beta_8 RNDsR_{it} \times InFDIs_{it} + \beta_9 RNDsR_{it} \times OutFDIs_{it} + \varepsilon_{it} \end{aligned} \quad (3)$$

where i = Korea's trading partner countries (16 countries) and t = year (1996–2003).

In model B the signs of β_1 and β_2 are expected to be positive for HEP-VIIT and negative for LEP-VIIT. In both cases, the signs of β_4 and β_5 are expected to be negative and those of β_3, β_6, β_7, β_8, and β_9 are expected to be ambiguous.

For model A and model B, R&D and FDI variables are most important determinants and the coefficients are testing the following hypotheses.

Hypothesis 1:

R&D stock differences between countries would increase (decrease) VIIT: $\beta_2 > (<) 0$

Hypothesis 2:

FDI would increase VIIT (efficiency-seeking): β_6 (inward), β_7 (outward) > 0

FDI would decrease VIIT (market-seeking): β_6 (inward), β_7 (outward) < 0

With the panel data set up, a random effects model is adopted for all analysis based on the Breusch-Pagan and Hausman tests. Groupwise heteroscedasticity is considered given this model's failure to pass the homoscedasticity test at the 5% significance level. For comparison, results from a random effects tobit model are also listed.

Econometric results and discussion

Table 2 summarizes the results obtained from model A. As expected, difference in physical capital endowment (*DGDPPC*) is positively related to VIIT whereas trade imbalance is negatively related to VIIT. However, the statistical impacts of differences in market size and distance are not significant. The most surprising result is that the sign of the coefficient of difference in technological capacity is the opposite of what we expected. From model A's viewpoint, the negative relationship is very puzzling.

Table 2. Random effects model estimation of South Korea's VIIT

	VIIT	
	Groupwise heteroscedasticity	Tobit
Const.	0.243 (0.71)	0.144 (2.14)**
DGDPPC	0.107 (1.69)*	0.127 (6.84)***
DRNDs	-0.008 (-1.65)*	-0.008 (-6.87)***
DGDP	0.116 (1.01)	0.102 (2.49)**
Distance	-0.045 (-0.56)	-0.027 (-1.73)*
TI	-0.124 (-3.12)***	-0.113 (-5.49)***
InFDIs	-0.003 (-0.12)	-0.008 (-0.31)
DRNDs*InFDIs	-0.033 (-2.33)**	-0.020 (-2.82)***
OutFDIs	-0.170 (-2.31)**	-0.074 (-0.61)
DRNDs*OutFDIs	-0.064 (-0.94)	-0.037 (-1.26)
N	128	128
R^2	0.545 (overall)	
Wald Chi^2 (p-value)	462.16 (0.00)	637.01 (0.00)

Note: z-statistics in parentheses. *, ** and *** : statistically significant at 10%, 5%, and 1% respectively.

As for FDI, only outward FDI from South Korea appears to have a statistically significant impact on VIIT as a reducing factor. This result supports the market-seeking FDI rationale. From the positive result of β_8, we can say that the impact of South Korea's R&D is strengthened by inward FDI. However, from the insignificant β_6, we cannot be sure about the direct impact of inward FDI.

Table 3. Random effects model estimation of South Korea's HEP- and LEP-VIIT

	HEP-VIIT		LEP-VIIT	
	Groupwise heteroscedasticity	Tobit	Groupwise heteroscedasticity	Tobit
Const.	0.364	0.363	0.302	0.318
	(15.35)***	(13.71)***	(1.85)*	(5.30)***
GDPPCR	0.040	0.043	-0.117	-0.076
	(3.40)***	(2.77)***	(-0.90)	(-2.02)**
RNDsR	-0.007	-0.006	0.085	0.060
	(-1.68)*	(-1.23)	(1.70)*	(4.22)***
GDPR	-0.004	-0.004	-0.019	-0.022
	(-2.08)**	(-2.81)***	(-2.16)**	(-6.97)***
Distance	-0.097	-0.097	0.011	-0.003
	(-12.1)***	(-14.69)***	(0.23)	(-0.24)
TI	-0.032	-0.032	-0.086	-0.104
	(-2.89)***	(-3.19)***	(-2.43)**	(-4.82)***
InFDIs	-0.012	-0.006	0.472	0.369
	(-0.36)	(-0.15)	(1.74)*	(4.18)***
RNDsR*InFDIs	-0.024	-0.016	0.55	0.420
	(-0.68)	(-0.41)	(1.71)*	(4.42)***
OutFDIs	0.028	0.027	-0.194	-0.092
	(1.13)	(0.68)	(-1.97)**	(-1.05)
RNDsR*OutFDIs	0.057	0.055	-0.083	-0.061
	(3.21)***	(1.85)*	(-2.91)***	(-0.95)
N	128	128	128	128
R^2	0.688 (overall)		0.361 (overall)	
Wald Chi^2(*p*-value)	9677.84 (0.00)	282.01 (0.00)	4590.69 (0.00)	292.27 (0.00)

Note: *z*-statistics are given in parentheses. *, ** and *** statistically significant at 10%, 5%, and 1% respectively.

Table 3 shows the econometric results regarding the determinants of model B. Physical capital endowment has statistically significant and positive relation with HEP-VIIT only. Trade imbalance has statistically significant relation with the VIIT index in both cases, and distance only in the HEP-VIIT case as a reducing factor. The most informative results compared with the previous model (model A and Table 2) are those for the coefficients of the R&D and FDI variables. Although we expected the coefficient sign for *RNDsR* to be positive for HEP-VIIT and negative for LEP-VIIT, the result is the exact opposite. This shows that South Korea's R&D investment attenuates HEP-VIIT and enhances LEP-VIIT. In other words, these results indicate that South Korea's R&D activity is concentrated not on product innovation but on process innovation in order to produce standardized products at a lower price. Moreover, we can infer that these differing impacts of R&D on HEP-VIIT and LEP-VIIT invoked the puzzling empirical result in the aggregated VIIT model.

The inward and outward FDI have statistically significant impacts only on LEP-VIIT: Inward FDI is positively related to it and outward FDI is negatively related to it. The coefficient of inward FDI stock supports the product cycle theory, implying that South Korea is a southern country to which northern countries contribute FDI for the production of lower-quality (standardized) products. That implication could not be revealed by the aggregated VIIT model. Outward FDI from South Korea to OECD countries is in search of a lower-quality-product market, judging by the coefficient of *OutFDIs*. The coefficients of the interaction terms show that the impact of R&D investment is intensified with the inbound FDI level and enfeebled with the outbound FDI level, in accordance with the implication from each constituent variable's impact.

Additionally, the impact of market size, which was not significant in the aggregated VIIT model, indicates that the larger the partner country is, the more VIIT occurs with South Korea. Possible explanation is that GDP can be a proxy of economic scale. A larger domestic market affords more opportunity to utilize scale economies for industry. A negative relation between economic scale and VIIT is observed by Greenaway et al. (1999).

3. Conclusion

In this paper, we studied the characteristics of S.Korea's vertical intra-industry in the period from financial crisis to recovery (1996-2003). We found the prevalence of vertical intra-industry trade over horizontal IIT in South Korea's IIT with OECD countries and Taiwan. South Korea's VIIT is characterized by a lower export price, which indicates that relative to the OECD countries, South Korea is the southern country in a North-South trade model. By means of an econometric model, we show that the decomposition of VIIT into higher and

lower export price VIIT provides a feasible solution for puzzling results obtained with the more common, aggregated VIIT analysis. Moreover, the segregated analysis confirms that the determinants of VIIT can be different according to the type of VIIT and that a deeper understanding of the determinants' impact on VIIT is possible.

The following findings are drawn with regard to South Korea's VIIT with the OECD countries. First, the main determinant of HEP-VIIT is physical capital endowment, whereas the more important factors affecting LEP-VIIT are R&D investment and FDI. Second, South Korea's R&D focuses on price competitiveness. Lastly, South Korea's inward FDI is efficiency-seeking FDI, whereas its outward FDI is market-seeking FDI, substituting for LEP-VIIT.

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Appendix

DGDPPC = the absolute difference in GDP per capita between South Korea and the trading partner country. The value is in year 2000 constant dollars. The data source is International Monetary Fund, World Economic Outlook Database, September 2006.

DRNDs = the absolute difference in R&D stock per worker. The R&D expenditure amount is the constant purchasing power parity (PPP) dollar of year 2000. Data from the OECD's Main Science and Technology Indicators are used. The conversion from expenditure to stock is accomplished by the perpetual inventory method based on Coe and Helpman (1995) with a 5% depreciation rate.

DGDP = the absolute difference in GDP. The value is in year 2000 constant dollars. The data source is the same as for *DGDPPC.*

Distance = logarithm of the distance in nautical miles from Seoul (capital of South Korea) to the capital of the trading partner country. The Internet source www.timeanddate.com/worldclock/distance.html is used.

InFDIs = the ratio of inward FDI stock from the trading partner country to South Korea over the bilateral total trade volume calculated in year 2000 PPP dollars. The flow values are converted to constant PPP dollars of South Korea, year 2000, and stock was calculated from flow value using a depreciation rate of 10%. Data from South Korea's Ministry of Commerce, Industry, and Energy were used.

OutFDIs = the ratio of outward FDI stock from South Korea to the trading partner country over the bilateral total trade volume calculated in year 2000 PPP dollars. The unit and calculating method is the same as for *InFDIs.* Data from the Export-Import Bank of South Korea were used.

GDPPCR = South Korea's GDP per capita / Trading partner's GDP per capita. The data source is the same as for *DGDPPC.*

RNDsR = South Korea's R&D stock per worker / Trading partner's R&D stock per worker. The data source is the same as for *DRNDs.*

GDPR = South Korea's GDP / Trading partner's GDP. The data source is the same as for *DGDP.*