Intra-Industry trade of EU-15 countries: New aspects

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ABSTRACT

We argue some features of Intra-industry trade which the conventional measures on IIT fails to capture and proposes to add some additional measures to better capture the nature of IIT. First, arguing that Grubel-Lloyd index only concerns the share of IIT, we propose to see the evolution of the number of IIT products. Second, we show that the conventional classification into Horizontal and Vertical IIT is arbitrary and is not innocuous. Instead we propose a new measure of unit value difference of IIT products, which we call "unit value difference measure of IIT". While we provide all the information of IIT index, number of IIT products, and unit value difference measure of IIT for EU 15 countries for the period of 1988 – 2007 in separate files, we focus our analysis to EU15's IIT with the Eastern European countries and China in this main text. We find, among others, a dramatically increasing number of IIT products with China, a generally increasing number of IIT products with Eastern European countries, China's concentration into low quality goods, which has not changed even in recent years, and the Eastern European countries' rise in quality goods.

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I. INTRODUCTION

It is widely documented that the volume of Intra-Industry Trade (IIT) expanded dramatically with the worldwide trade liberalization, especially in the past few decades. The last few decades saw many studies on IIT both in its measurement and determinants analysis. The recent literature on IIT shed light on product level analysis and prices at minute product level because 1) many developing countries join the world trade system and the price of a particular product between a pair of countries is often substantially different (increased number of trade partners), and 2) more varieties of products with various prices and quality are able to export due to a fall of trade costs (increased number of products). Many papers in the literature have tackled these issues by classifying two types of IIT, i.e. horizontal IIT (HIIT) and vertical IIT (VIIT). HIIT is defined as IIT without substantial per-unit export and import price gap, while VIIT is as the one with substantial per-unit export and import price gap.

Keeping on the current stream, this paper focuses on EU-15 countries foreign trade. In particular it is worthwhile to currently discuss several outstanding issues and questions in EU trade related to China and Eastern European economies. It is of interest not only how China's IIT index with EU countries is evolving over the 1990s and 2000s, when China rapidly emerges as the major country of the world trade, but also how the number of IIT products has changed over time. Moreover, the evolution of export-import price difference of China's IIT with EU countries is an issue of interest both from academic point of view and policy point of view. The above argument also applies for Eastern European countries in a different context, which have rapidly deepened their economic ties with EU 15 countries and finally joined the EU. It is of utmost concern for Eastern European countries whether or not IIT has increased and whether or not their products have been climbing up the quality ladder, as they have deepened economic integration with EU-15 countries.

Our contributions to the literature are three-fold. First, it provides some evidences on the evolution of the *number* of IIT products. Second, it proposes some alternative measures of quality difference of IIT. These allow us to see the nature of IIT from different angles. Third, this paper provides an almost comprehensive picture of the evolution of Grubel-Lloyd index over 20 years for the top 30 trade partners of each EU 15 country at HS 8 digit product level, which is as far as we know, one of the largest and longest samples in the literature as discussed below.

Our analysis yields several findings. First, Grubel-Lloyd index of major EU countries, such as Germany, France, United Kingdom, and Italy, with China are generally in upward trend. The other EU 15 countries' Grubel-Lloyd index with China are stable or in upward trend. Second, the numbers of IIT products of EU 15 countries with Eastern European countries are generally in upward trend, except Germany whose numbers of IIT products stay almost constant after the middle of 1990s. A dramatic increase of the numbers of IIT products of EU 15 countries with China is documented.

Third, China's IIT with EU 15 is generally characterized by IIT where the unit price of China's exports to EU 15 are lower than the unit price of China's imports from EU 15. Moreover, this price gap is not in decreasing trend even in the recent years. This finding indicates that while China rapidly expands its range of export products and its spectrum of export products gets similar to that of developed countries, which is also documented by Rodrik (2006) and Schott (2008) , there is still a large gap in unit prices and the gap is not narrowing. Forth, a clearly increasing trend of horizontal IIT (HIIT) between pairs of major EU countries such as Germany, France, Italy and Eastern European countries is documented. The previous literature finds a large proportion of vertical IIT (VIIT) between EU 15 and Eastern European countries, but this paper shows the ratio is clearly decreasing. This finding implies that Eastern European countries goods are climbing up "quality ladder".

Literature

Greenaway et al. (1995) gives a unified interpretation of the theories on the determinants of IIT and points out that the determinants and/or expected signs are different between HIIT and VIIT. Thus, it proposes to decompose the conventional IIT index of Grubel and Lloyd (1975) into HIIT and VIIT by unit value export-import price difference. Using UK trade data of the year 1988 at SITC 5 digit, the empirical part of the paper supports the above claim. While Greenaway et al. (1995) involves cross-country analysis without any time dimension, Aturapane et al. (1999) studies the determinants of HIIT and VIIT using trade data between EU and eight Central and Eastern European transition economies from 1990 to 1995. Fukao et al. (2003) constructs a model where a crucial factor of VIIT is FDI related trade. It shows that, in Asia, VIIT is dominant, which is driven by Japanese foreign direct investment (FDI). [1]

Closer to our interest of quality and unit prices, Jensen and Luthje (2009) analyses the determinants of HIIT and VIIT using bilateral trade data between pairs of EU-15 countries and four Eastern European countries: Hungary, Slovakia, Poland and the Czech Republic at HS 6 digit level for 1996-2005. It argues the importance of demand side for the study of IIT determinants, such as the overlap of income level. Our paper covers longer period and analyzes at higher disaggregated level in order to better capture the quality difference by the difference in unit prices. Another paper close to ours is Fontagné et al.(1997). Using European trade data at the same aggregation level with our paper, their analyses show, among others, an increase of IIT within EU countries and an ever increasing share of VIIT. However, the period of their study is only up to 1994. We will show that different pictures emerge when we extend the period and examine IIT of a *pair* of countries. Whereas all the above

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1 Ando (2006) analyses HIIT/VIIT in machinery sector and finds that VIIT is rapidly increasing in that sector in Asia but the nature of this VIIT trade is not quality difference but the expanding back-and-forth trade of machinery parts and components. Okubo (2006) shows that Japan's IIT with non-OECD countries, especially Asian countries, are driven by technology transfer by Japanese FDI firms.

papers are on the determinants of HIIT/VIIT, this paper's scope is descriptive but it offers a comprehensive picture of IIT from several angles. Our data cover a much longer period and are at most disaggregated level, an important element for the analysis on the quality difference of products. In terms of its comprehensive treatment, Brulhart (2009) is similar to ours. It provides a comprehensive description of global IIT and inter-industry trade patterns using worldwide trade data at HS 6 digit. However our paper differs from his in that one of our main focuses is the quality difference of IIT and that we conduct the analysis at more disaggregated level.

Plan of paper

The rest of the paper is organised as follows. The next section explains the data and Grubel-Lloyd IIT index. Section III shows some stylised facts on the evolution of IIT (Grubel-Lloyd) and on the number of IIT products at 8 digit product code. Section IV presents HIIT and VIIT index with various threshold levels, pointing out a problem of using an arbitrarily chosen threshold level. Section V focuses on quality issue of IIT and proposes a way to capture the quality difference of IIT. The final section concludes.

II. DATA AND GRUBEL-LLOYD IIT INDEX

We use Eurostat trade data, which cover exports and imports[2] of EU countries at 8 digit HS code with the maximum period of 20 years, from 1988 to 2007. There are 17249 HS 8-digit codes in total. Since our focus is IIT and its unit price difference, we confine our analysis to manufacturing sector. 13173 HS 8-digit codes correspond to manufacturing sector. Although a great advance in the study of IIT has been achieved by the predecessors, we think that the existing IIT index alone captures only a part of the nature of IIT, which we discuss in the subsequent chapters. The measures of IIT commonly used in the previous literature are Grubel-Lloyd index and its variant, HIIT index and VIIT index.

The well-known classical Grubel-Lloyd (1975) index of product category k is defined as:

$$IITindex_k = 1 - \frac{\left|Ex_k - \mathrm{Im}_k\right|}{Ex_k + \mathrm{Im}_k}$$

where the second term represents the index of *inter*-industry trade. The index of *intra*-industry trade is computed as one minus the index of *inter*-industry trade, namely as the residual.

[2] Exports data are FOB basis while imports data are C&F or CIF (depending on whether suppliers provide insurance) basis. Thus, we should bear that in mind when we compare the unit price of IIT.

III. GL IIT INDEX-SOME STYLIZED FACTS

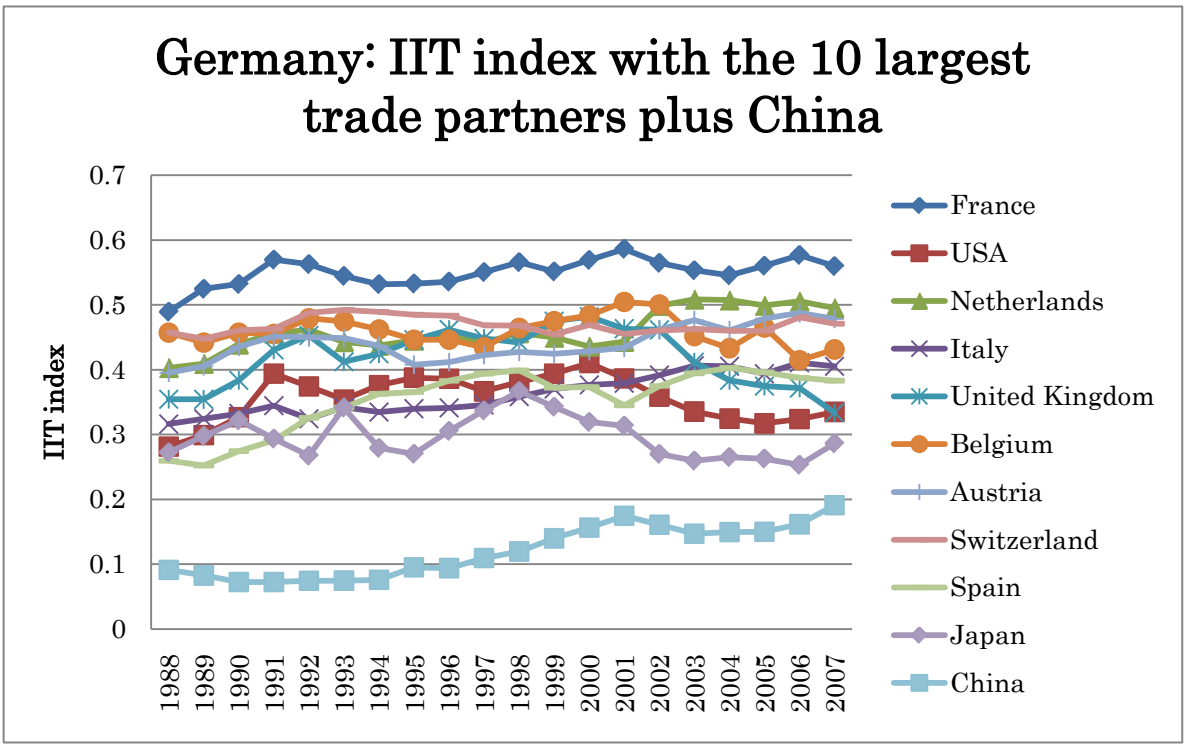
III.1. *GL Index and Trade Partners*

To compute an aggregate index of total IIT between two countries, the usual way in the literature (see Jensen and Lüthje (2009), for example) is to put weight by the share of trade values. We compute Grubel-Lloyd index of each EU 15 country with each country's Top 30 trade partners in the world. Grubel-Lloyd index between country i and country j is defined as above, namely:

$$IITindex_{ij} = \sum_{k=1}^{K}\left(\left(\frac{Ex_{ijk}+\mathrm{Im}_{ijk}}{\sum_k\left(Ex_{ijk}+\mathrm{Im}_{ijk}\right)}\right)\bullet\left(1-\frac{\left|Ex_{ijk}-\mathrm{Im}_{ijk}\right|}{Ex_{ijk}+\mathrm{Im}_{ijk}}\right)\right) \qquad (1)$$

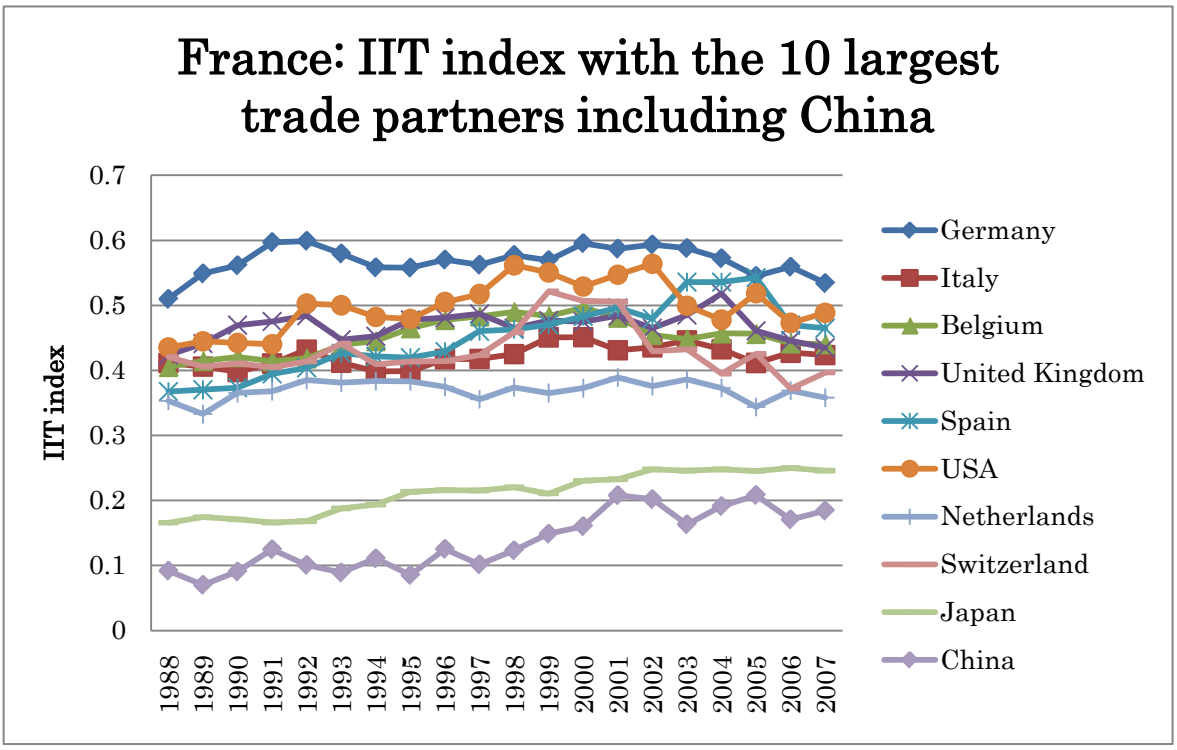
Using (1), Figure 1 and Figure 2 show the evolution of Grubel-Lloyd IIT index of Germany and France with the 10 largest trade partners[3] plus China. We show the cases of Germany and France as representative countries and spare showing other EU 15 countries' case due to space constraint. For all the other EU countries' cases, see the addendum of this paper, which is prepared as a separate file. IIT index with the largest trade partners are in the range of 0.4 - 0.5 and stay almost at the same level over time. IIT index with China, are much lower than the other partner countries in the top 10. It was around 0.1 at the starting year, i.e., 1988 and has gradually risen to 0.2 in the year 2007.

Figure 1: Germany - IIT index with the 10 largest trade partners plus China (ranked 11th.)



[3] The criterion is the sum of total values of imports and exports over the whole period, i.e., 1988-2007.

Figure 2: France - IIT index with the 10 largest trade partners including China

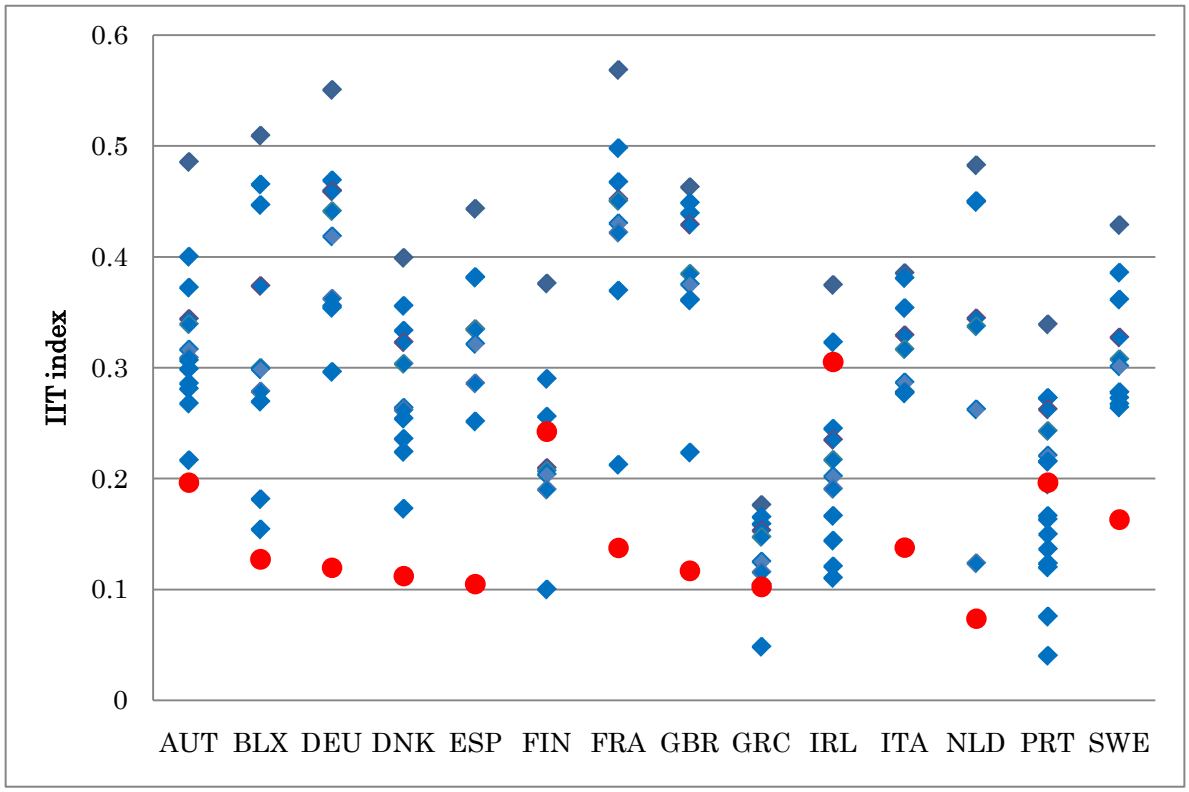


To see if the above finding of low IIT index with China is a general phenomenon for all EU 15 countries, Figure 3 shows each EU-15 country's IIT index with its largestest trade partners including China[4]. The red round dots represent IIT index with China, while the blue square dots represent the other major trade partners. In ten EU countries out of the total fourteen EU-15 countries[5], China registers the lowest IIT index. Moreover, in the case of Germany, Spain, France, United Kingdom, Italy, Netherlands and Sweden, China's IIT index numbers are outliers, or at least much lower than the IIT index numbers of the other countries.

Figure 3: China's IIT index in comparison with other major trade partners for each EU-15 country

[4] For each EU-15 reporter country, we have taken trade partners which have higher total trade values than China. For example, for the case of Germany, the top 10 trade partners of Germany plus China (ranked 11) are included in the data. For the case of Portugal, the top 17 trade partners of Portugal plus China (ranked 18) are included in the data.

[5] The total number of countries is 14 instead of 15 because Belgium and Luxembourg is registered as one "country" (=reporter) in the original EU trade data from 1995.



The other partner group we have chosen for analysis is Eastern European countries[6]. Figure 4 and Figure 5 show IIT index with Eastern European countries of Germany and France, respectively. We notice that IIT index of Germany with Eastern European countries exhibits an increasing trend while that of France shows no particular trend. An increasing trend found for Germany is not discerned in the other EU 15 countries, either. Another interesting finding is that the levels of IIT index of Germany with Eastern European countries, especially with Czech (around 0.5) and Poland (from 0.3 to 0.4) is close to the levels with the major large trade partners (e.g. with France, Netherlands or Belgium) we have seen in Figure 1. Almost the same is true in French IIT with Eastern European countries (Figure 5).

Figure 4: Germany - IIT index with Eastern European countries

[6] There are several definitions for Eastern European countries. We selected EU countries as of 2007 which are classified as Eastern European countries by the United Nations. The selected countries are: Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia

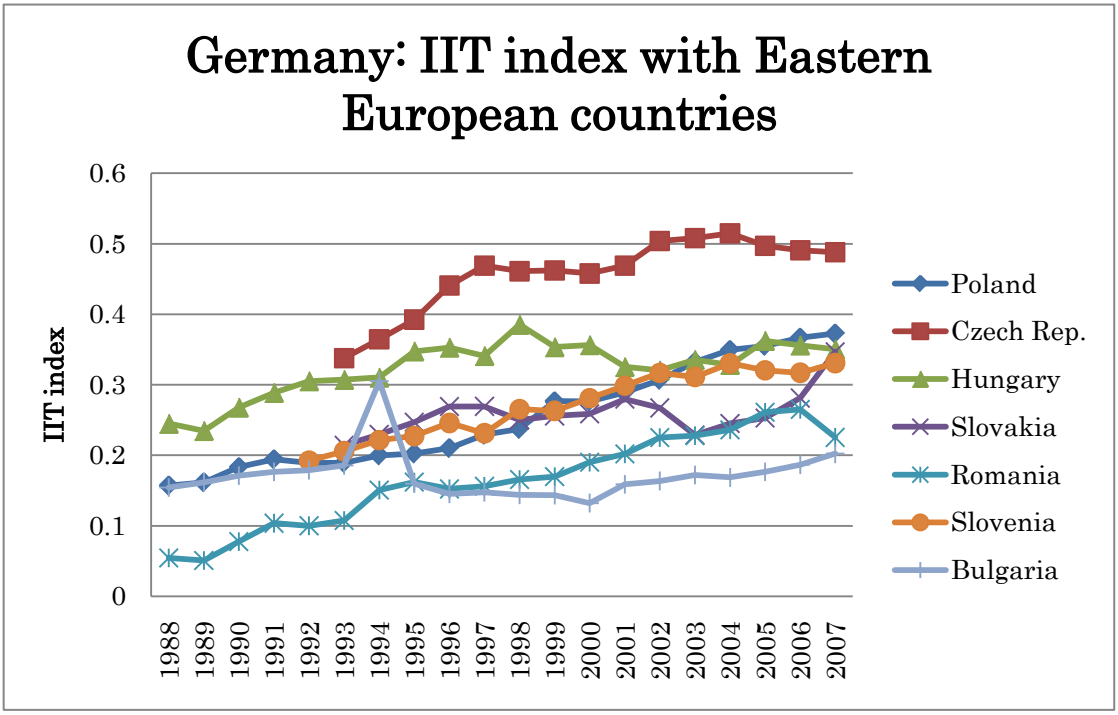
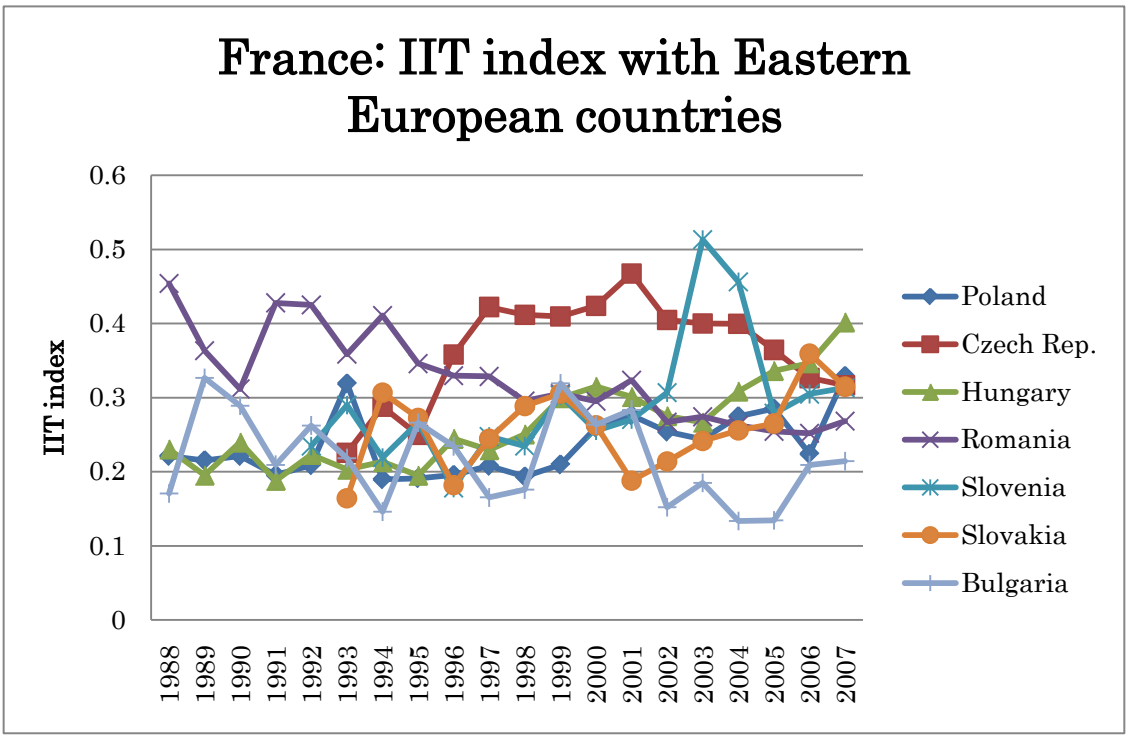


Figure 5: France - IIT index with Eastern European countries



III.2. *Evolution of the number of IIT products*

Although Grubel-Lloyd IIT index shows us one important aspect of IIT, i.e., the ratio of the "overlap" of export and import values of the same products, it gives us no information on the number of IIT products because what affects Grubel-Lloyd IIT index between country i and country j is each product's IIT index and its share in total trade value. For example, suppose that there are only two

goods. Grubel-Lloyd index of one good is 0.2 and its trade share (weight) is 0.5. Grubel-Lloyd index of the other good is 0.8 and its trade share (weight) is 0.5. Then, the aggregate Grubel-Lloyd index is 0.5 (=0.2 x 0.5 + 0.8 x 0.5). Suppose the number of IIT products has increased to six. Assume further that Grubel-Lloyd index of the first good is 0.2 and those for the second to the sixth good is 0.8. If trade values have increased such that the trade share (weight) of the first good is 0.5 as in the original case, and those for the second to the sixth good are 0.1 each, which makes the aggregate trade share of the second to sixth good 0.5. Then, the aggregate Grubel-Lloyd index stays the same (0.2x0.5+0.8x0.1x5=0.5) even though the number of IIT products has expanded from two to six and the IIT trade values have increased. A simple numerical example of this argument is in Appendix A.2. The neutrality of existing Grubel-Lloyd index in the number of IIT products may misleadingly make us believe that there is no change in the nature of IIT.

Figure 6 and Figure 7 show the evolution of the number of IIT products with the 10 largest trade partners (including or plus China) of Germany and France, respectively. By looking at the evolution of the number of IIT products, we can see other dimension of IIT, which the conventional GL-index alone does not show. While GL IIT index with China shows an increase from around 0.1 to 0.2 as we have seen above, the number of IIT products with China registers an outstanding and drastic increase. This dramatic increase of IIT products with China is a common phenomenon for all the EU countries.

Figure 6: Germany – Number of IIT products with the 10 largest trade partners including (or plus) China

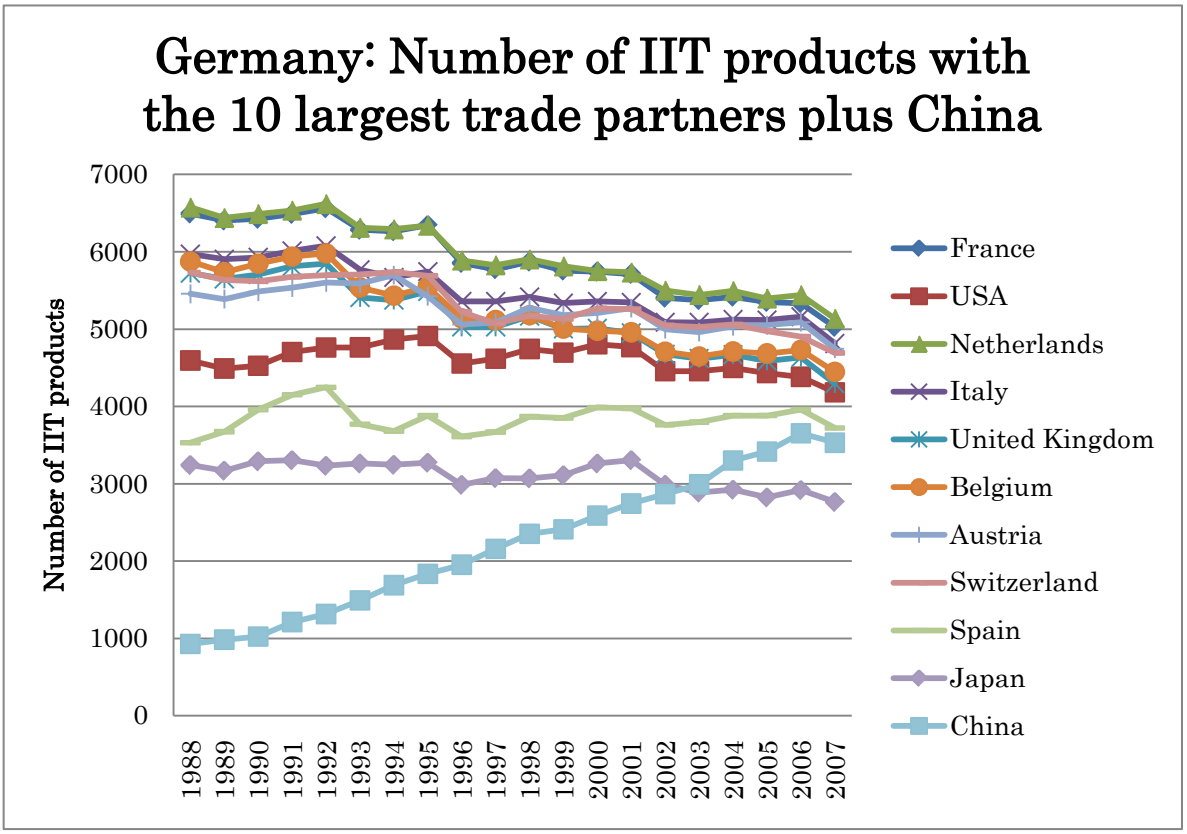
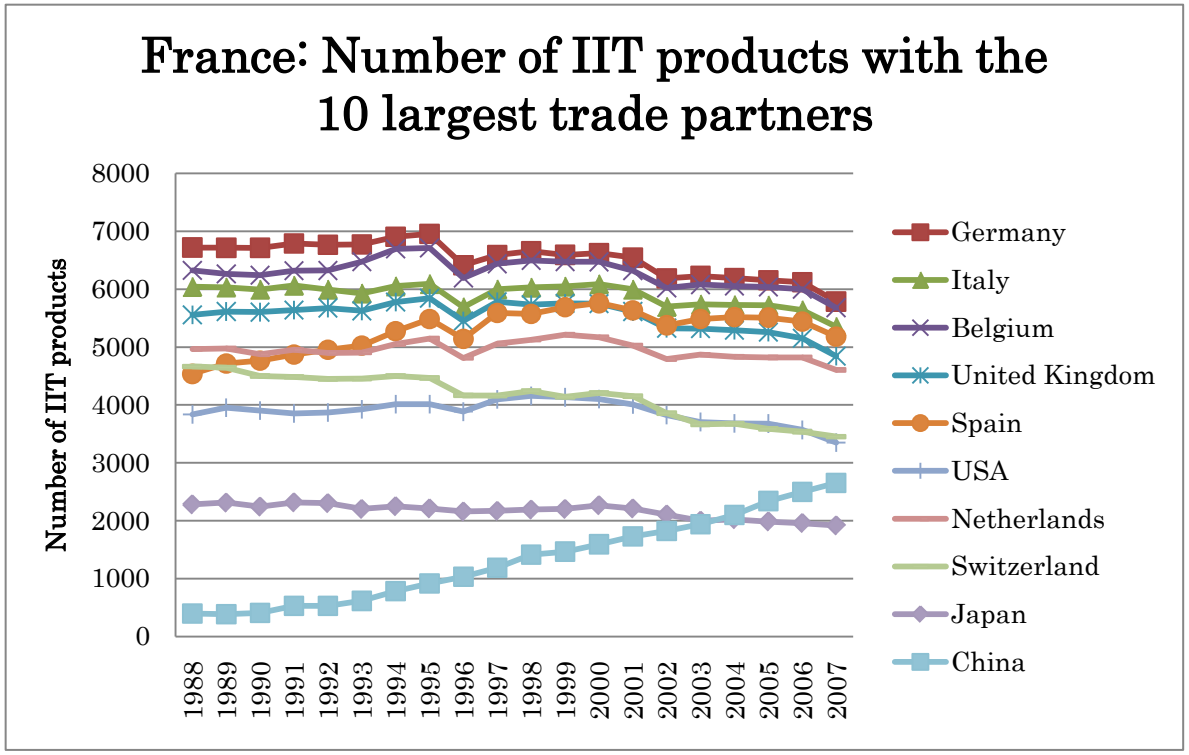


Figure 7: France – Number of IIT products with the 10 largest trade partners including China (ranked 10th)



The cases with the Eastern European countries are in Figure 8 and Figure 9. Here the case of Germany and France show different pictures. The number of IIT products of Germany with Eastern European countries increases up to the middle of 1990s and then stays almost constant. Unlike the case of Germany, the numbers of IIT products of France with Eastern European countries show clearly increasing trend, i.e., high *growth rates*. This clearly increasing trend is also documented in the other EU 15 countries. Namely, there is a clear difference between Germany and the other EU 15 countries in terms of the evolution of its number of IIT products with the Eastern European countries.

While we argue the evolution (*change*) of the number of IIT products above, when we look at the *levels* of the number of IIT products, there is a difference between Germany and the other major EU countries vis-à-vis Eastern European countries. The level of the number of IIT products of Germany with Eastern European countries is substantially higher than those of the other major EU countries already at early stage of the period in study. This dichotomous difference between Germany and the other three EU countries in the number of IIT products coincides with the other dichotomous difference between Germany and the other major EU countries in GL IIT index we have seen above in Section III-1. Namely, GL IIT index of Germany with Eastern European countries exhibits an increasing trend while those of the other three major EU countries do not. This coincidence indicates that the newly emerged IIT products for France, Italy and the UK with Eastern European countries do not yet have either large trade value shares or large individual IIT index (i.e., the overlapped parts

of exports and imports are not yet high), whereas Germany's IIT with Eastern European countries have been well established already by the middle of 1990s and it reached the stage of large trade values and large individual (product level) IIT index.

Figure 8: Germany – Number of IIT products with Eastern European countries

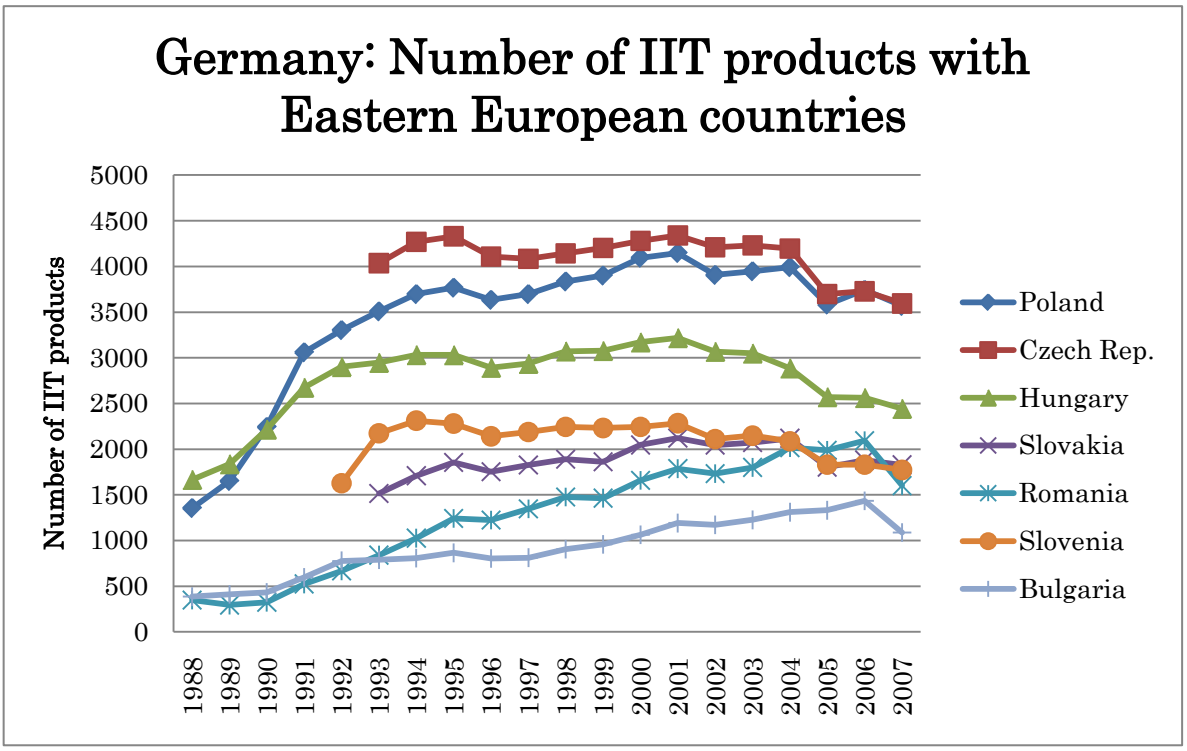
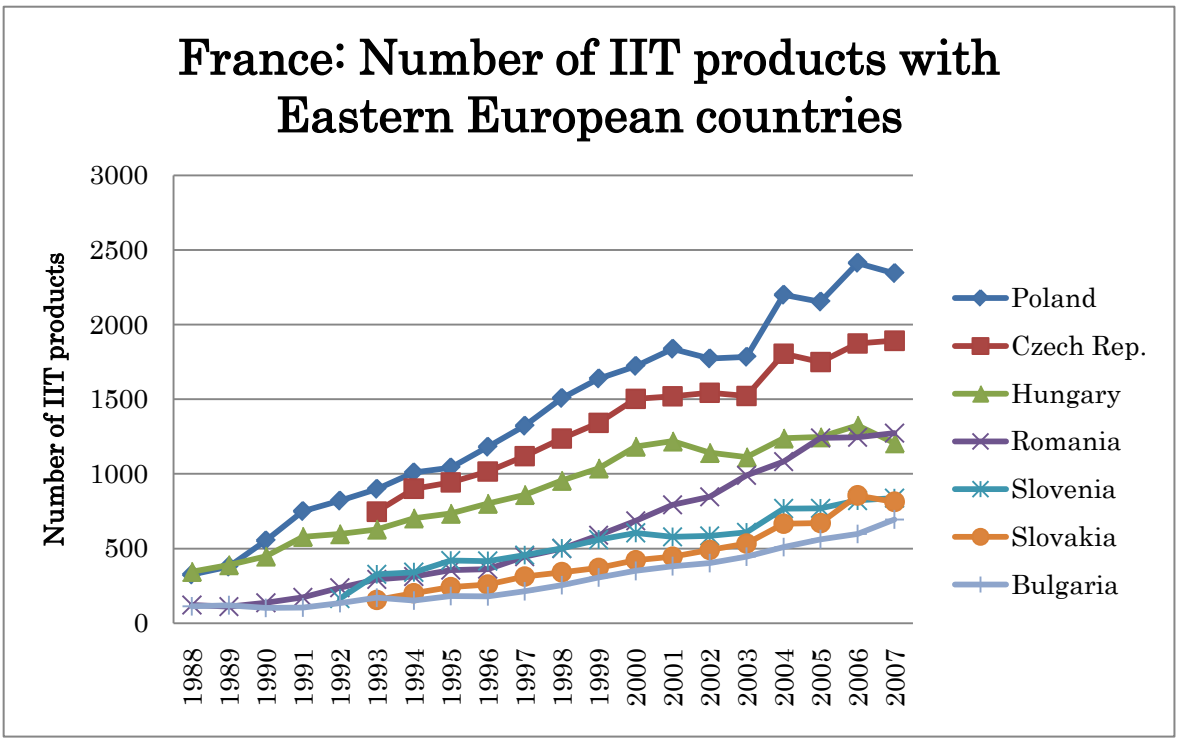


Figure 9: France – Number of IIT products with Eastern European countries



To check this hypothesis, we estimate the following equation for German data and the whole EU15 data by several levels of the number of IIT products.

$$IITindex_{ijt} = \beta_0 + \beta_1 NumberIIT_{ijt} + \tilde{\beta}_2 Year + \tilde{\beta}_3 Pair + \varepsilon_{ijt}$$

where $IITindex_{ijt}$ is IIT index of reporter country i with partner country j at time (year) t; $NumberIIT_{ijt}$ is the number of IIT products of reporter country i with partner country j at time (year) t; *Year* is a vector of year dummies; *Pair* is a vector of reporter-partner pair dummies; and ε_{ijt} is iid error. The variables $IITindex_{ijt}$ and $NumberIIT_{ijt}$ are transformed to natural logs.

Germany's case (Table 1) indicates that there is a positive correlation between the number of IIT products and IIT index for the whole data (1st column) and the coefficient estimates gets higher as the levels of the number of IIT products increases and it reaches the highest for the sub-sample of the number of IIT products between 3000 and 5000, which corresponds to the numbers with the Eastern European countries. Table 2 shows the regression results using the whole EU 15 countries data. The negative coefficient estimate for the whole data (1st column) is different from the case of Germany only we found in Table 1, but the coefficient estimate is very small. On the other hand, the coefficient estimates gets higher as the levels of the number of IIT products increase as in the case of Germany alone (Table 1).

Table 1: Regressions of IIT index on the number of IIT products: Germany

Regressions by the levels of IIT numbers: Germany

	(1)	(2)	(3)	(4)	(5)
	WholeData	IITless1000	IIT1000_3000	IIT3000_5000	IIT5000_7000
ln_NumberIIT	0.298***	0.248	0.415***	0.747***	-0.149
	(8.30)	(1.78)	(6.73)	(5.08)	(-0.57)
Constant	-3.708***	-3.788***	-4.960***	-7.409***	0.513
	(-13.66)	(-4.02)	(-11.02)	(-6.03)	(0.23)
R-squared	0.296	0.222	0.514	0.498	0.560
Number of observations	931	239	416	158	118

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Regressions of IIT index on the number of IIT products: Whole EU 15

Regressions by the levels of IIT numbers: EU15 Whole Data

	(1)	(2)	(3)	(4)	(5)
	WholeData	IITless1000	IIT1000_3000	IIT3000_5000	IIT5000_7000
ln_NumberIIT	-0.0618***	-0.0776***	0.152***	0.337***	0.422***
	(-5.28)	(-4.76)	(5.24)	(7.94)	(5.34)
Constant	-1.541***	-1.728***	-2.730***	-3.844***	-4.391***
	(-24.07)	(-23.83)	(-12.72)	(-10.98)	(-6.51)
R-squared	0.564	0.436	0.796	0.849	0.870
Number of observations	12470	8529	2680	832	429

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Thease results suggest that the IIT index of the other major EU countries vis-à-vis Eastern European countries may increase in years to come. The same might be said for China. Namely, China's IIT index may increase substantially in years to come.

IV. HORIZONTAL AND VERTICAL IIT INDEX

This section computes Horizontal and Vertical IIT index using some representative country pairs, i.e. Germany with Poland and China. Following the existing literature we can distinguish between HIIT and VIIT by per-unit export-import price difference at product level (k) with a certain threshold value (x), in which HIIT products are satisfied with $\frac{1}{1+x} < \frac{Export\,\mathrm{Pr}ice_k}{\mathrm{Im}port\,\mathrm{Pr}ice_k} < 1+x$ and VIIT is satisfied with $\frac{Export\,\mathrm{Pr}ice_k}{\mathrm{Im}port\,\mathrm{Pr}ice_k} < \frac{1}{1+x}$ *or* $\frac{Export\,\mathrm{Pr}ice_k}{\mathrm{Im}port\,\mathrm{Pr}ice_k} > 1+x$.

We compute HIIT and VIIT index following Greenaway et al. (1995) at various threshold levels, 5 percent (x=0.05), 10 percent (x=0.1), 15 percent (x=0.15), ...50 percent (x=0.5). Greenaway et al. (1995) proposes to sort k's product into Horizontal category and Vertical category using several threshold levels, such as 15 percent or 25 percent. In symbols, Greenaway et al. (1995) decomposes Grubel-Lloyd index of equation (1) into HIIT index and VIIT index:

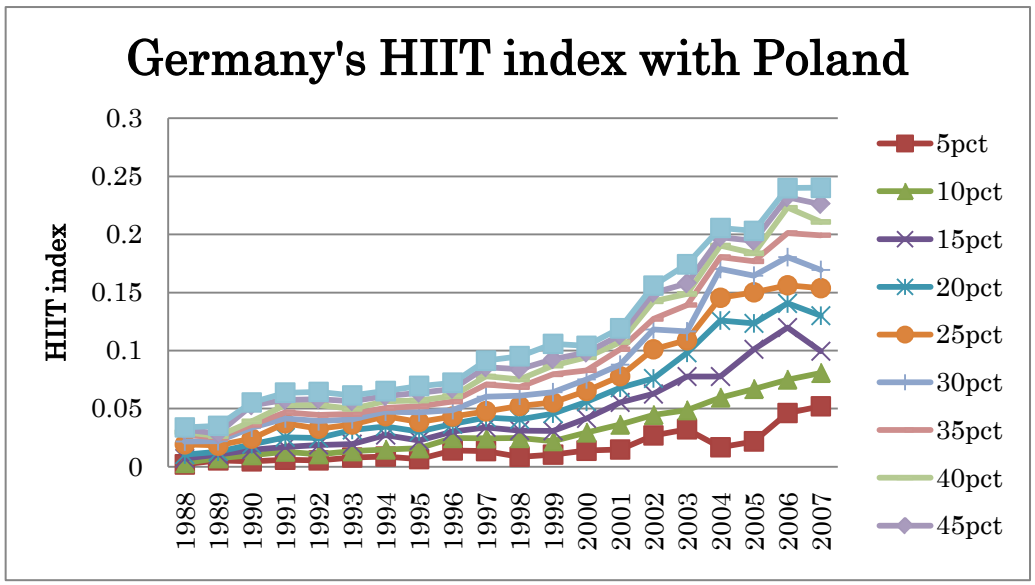
$$\underbrace{\sum_{k=1}^{K}\left(\left(\frac{Ex_{ijk}+\mathrm{Im}_{ijk}}{\sum_k\left(Ex_{ijk}+\mathrm{Im}_{ijk}\right)}\right)\bullet\left(1-\frac{\left|Ex_{ijk}-\mathrm{Im}_{ijk}\right|}{Ex_{ijk}+\mathrm{Im}_{ijk}}\right)\right)}_{\text{IIT index}}=$$

$$\underbrace{\sum_{h=1}^{H}\left(\left(\frac{Ex_{ijh}+\mathrm{Im}_{ijh}}{\sum_{h}\left(Ex_{ijh}+\mathrm{Im}_{ijh}\right)}\right)\bullet\left(1-\frac{\left|Ex_{ijh}-\mathrm{Im}_{ijh}\right|}{Ex_{ijh}+\mathrm{Im}_{ijh}}\right)\right)}_{\text{HIIT index}}+\underbrace{\sum_{v=1}^{V}\left(\left(\frac{Ex_{ijv}+\mathrm{Im}_{ijv}}{\sum_{v}\left(Ex_{ijv}+\mathrm{Im}_{ijv}\right)}\right)\bullet\left(1-\frac{\left|Ex_{ijv}-\mathrm{Im}_{ijv}\right|}{Ex_{ijv}+\mathrm{Im}_{ijv}}\right)\right)}_{\text{VIIT index}} \quad (2)$$

We note that all IIT trade products must be always classified as either HIIT or VIIT, i.e.K=H+V.

The previous literature uses the threshold levels from 15 percent to 25 percent and some papers such as Fukao et al. (2003) uses 35 percent. However, there is no firm reason and no theoretical support for the choices of these threshold levels.[7] Greenaway et al. (1995) allege that their result is robust against the choice of threshold levels. This is partly because they apparently take some threshold levels which are relatively close such as the percentages from 15 to 35 percent and partly because the focus of their analysis is the determinants of HIIT and VIIT, i.e., the *marginal* effect of the determinants, not the levels of HIIT and VIIT. However, when we compare HIIT/VIIT index at two threshold levels which are not close, such as 10 percent and 40 percent, the choice of threshold seems to matter. For example, looking at Figure 10, which shows Germany's HIIT index with Poland, we notice that the larger the threshold levels the larger the growth rate of HIIT index. Moreover, when our focus is on *levels* of HIIT and VIIT, threshold levels matter much. In fact, Figure 10 shows that, in the year 2007, HIIT index is approximately 0.1 at the threshold level of 15 percent while it is 0.2 at the threshold level of 35 percent. Furthermore, when we hope to look at the change of the index *over time*, the choice of threshold levels also matters. The same figure shows that the evolution of Germany's HIIT index over 20 years substantially differs depending on the chosen threshold levels.

Figure 10: Germany's HIIT index with Poland



[7] Fukao et al. (2003) argues that they raise the threshold level in order to take into account the exchange rate fluctuation, but still the difference of 10% (35% minus 25%) has no firm reason. In other words, the additional allowance is not something endogenously computed but something exogenously given.

The products whose IIT price differences are above 1.15 or below 1/1.15 both enter the category of VIIT. We call products whose price difference are above 1.15 the "upper side" VIIT and those below 1/1.15 the "lower side" VIIT. The existing VIIT index does not take into account the upper or lower side of price difference. Figure 11 and Figure 12 show the evolution of the upper side VIIT index and the lower side VIIT index of Germany with Poland. The spread of the indices widens as years go by. These findings indicate that the choice of threshold levels matters.

The above argument implies that looking only at results with some particular threshold levels might lead us to erroneously believe in some non-robust findings. Thus, we should look at results at least with various threshold levels. Although we spare showing the cases of France in this text due to space constraint, similar pictures arise for France.

Figure 11: Germany's Upper side VIIT with Poland

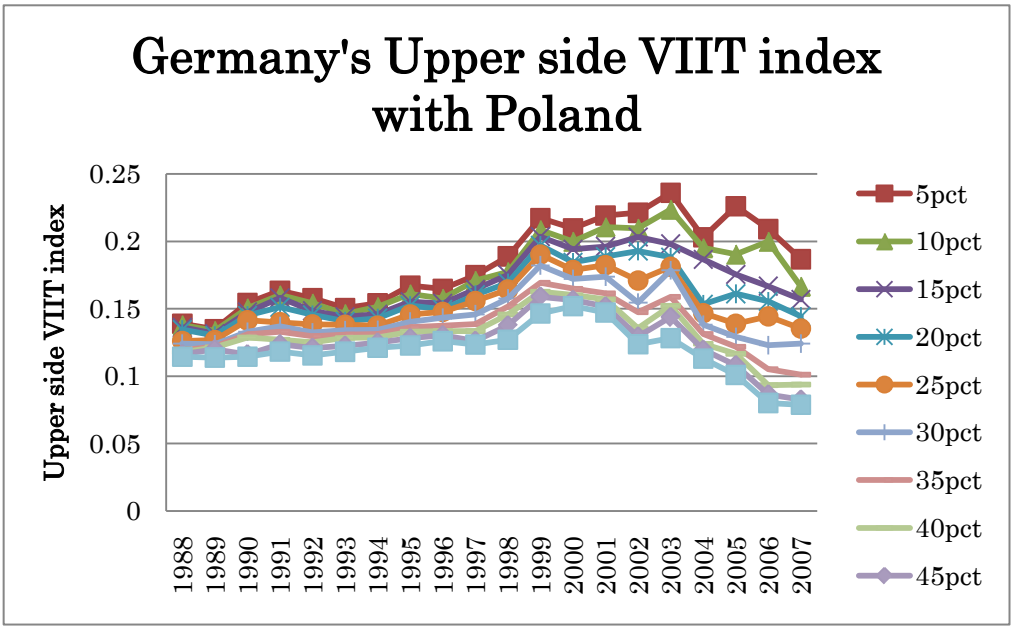
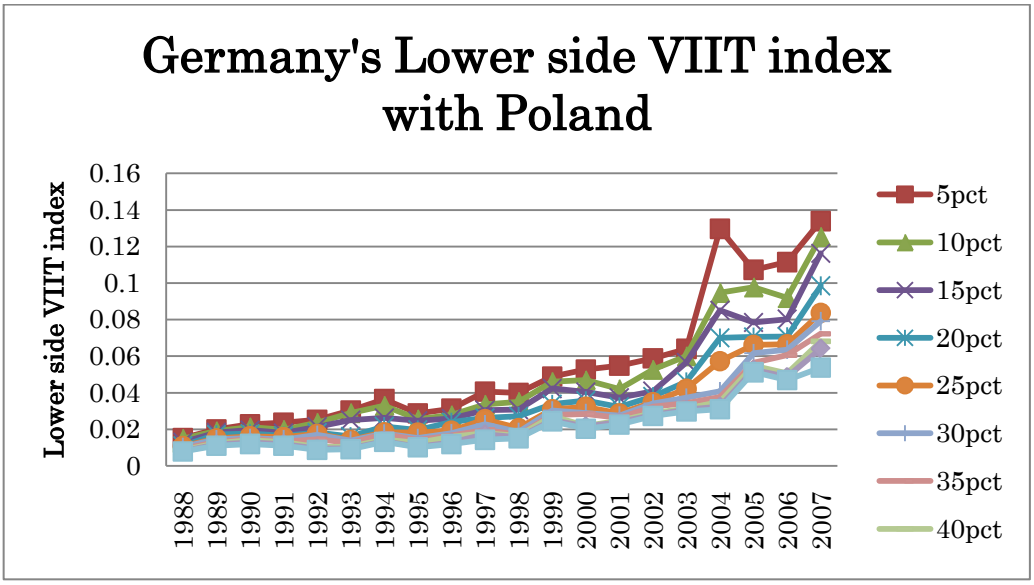


Figure 12: Germany's Lower side VIIT index with Poland



By looking at HIIT, the upper side VIIT and the lower side VIIT, at various threshold levels, in Figure 10, Figure 11, and Figure 12, together with GL index we have seen above, we find that Germany's IIT index with Poland steadily rises (Figure 4) and this increase is composed of the three elements: the increase of HIIT index number (Figure 10), the increase of the lower side VIIT index number (Figure 12), the decrease of the upper side VIIT index number after around 2003 (Figure 11). This indicates that Poland improved its product quality vis-à-vis Germany.

Turning our attention to the case of China, Germany's IIT index with China gradually increases (Figure 1). This increase can be decomposed into a slight increase of HIIT index (Figure 13), a clear increase of the upper side VIIT index (Figure 14) and no particular trend of the lower side VIIT index (Figure 15). These findings indicate that China's increase of its IIT with Germany is characterized by the expansion of lower quality IIT products.

Figure 13: Germany's HIIT index with China

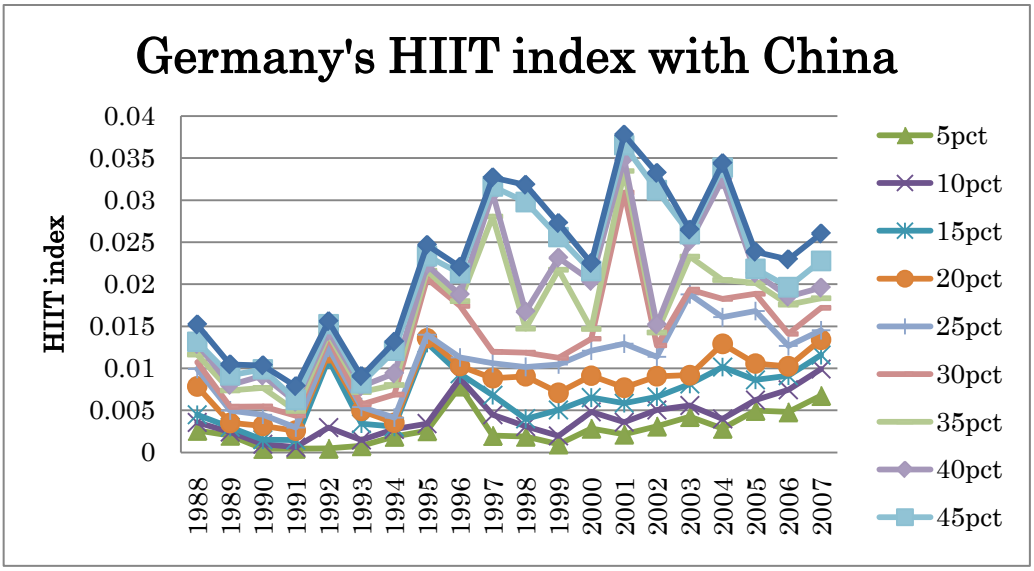


Figure 14: Germany's Upper side VIIT index with China

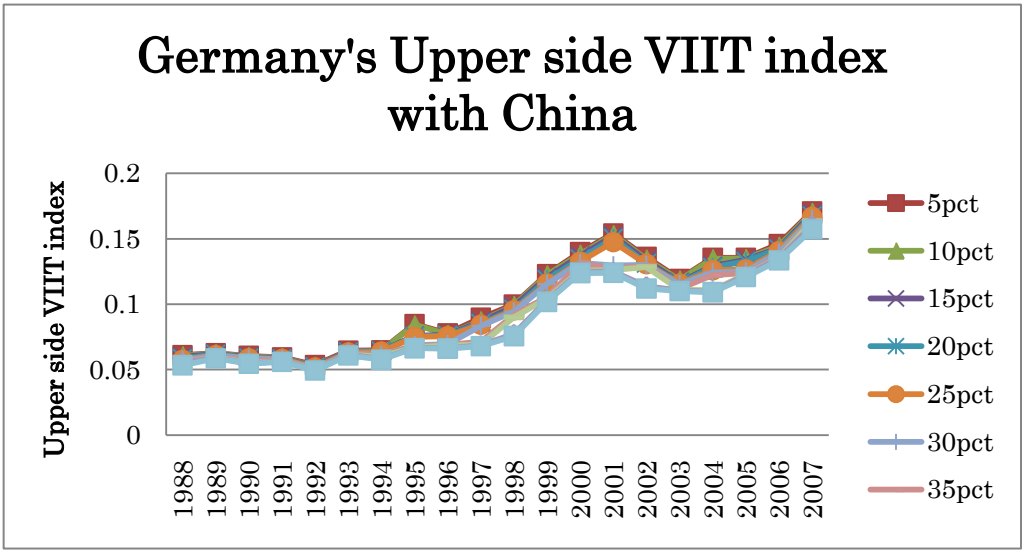
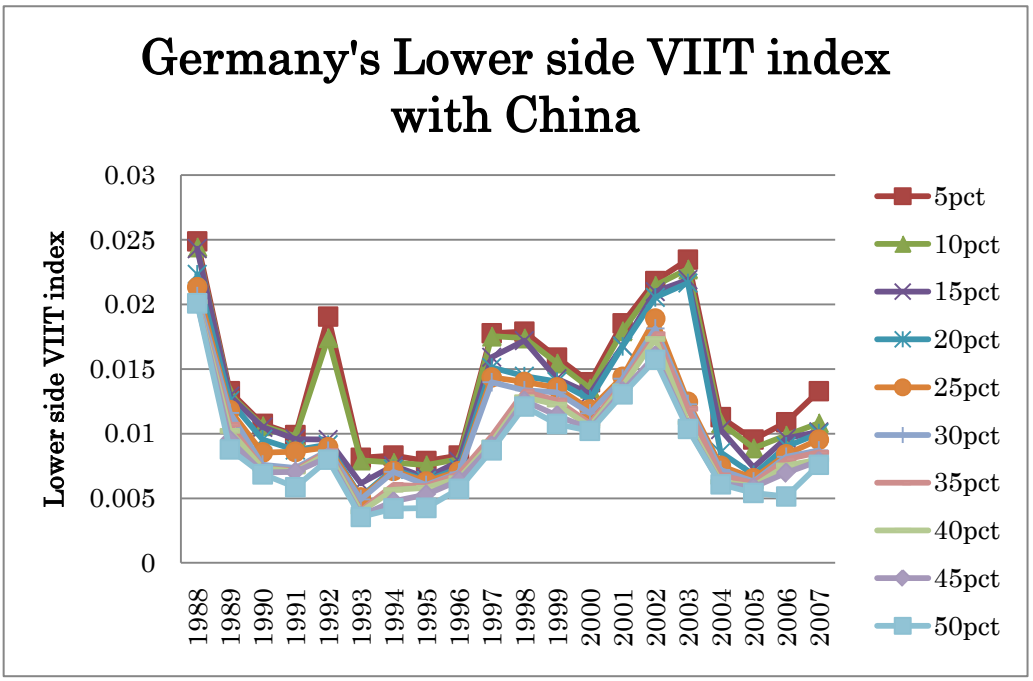


Figure 15: Germany's Lower side VIIT index with China



V. QUALITY DIFFERENCE AND IIT INDEX

One interesting issue we can extract from IIT data is how a pair of countries' trade is characterized by the difference in product quality. HIIT and VIIT index includes a feature of price difference but its focal nature is the same with the original IIT, namely, it represents the *share* of "overlap" of exports and imports. Information on price difference is used only for binary categorization into Horizontal and Vertical indices. In other words, products are sorted into either Horizontal or Vertical categories by a particular threshold level, but it does not matter how much the prices differ.

Instead, we like to focus on price difference of IIT without setting any thresholds. For this end, we propose two methods. One is to compute price difference of all IIT products and see the distribution. The other is what we call "unit value difference measure of IIT".

We define unit value difference as log of export price divided by import price, i.e.,

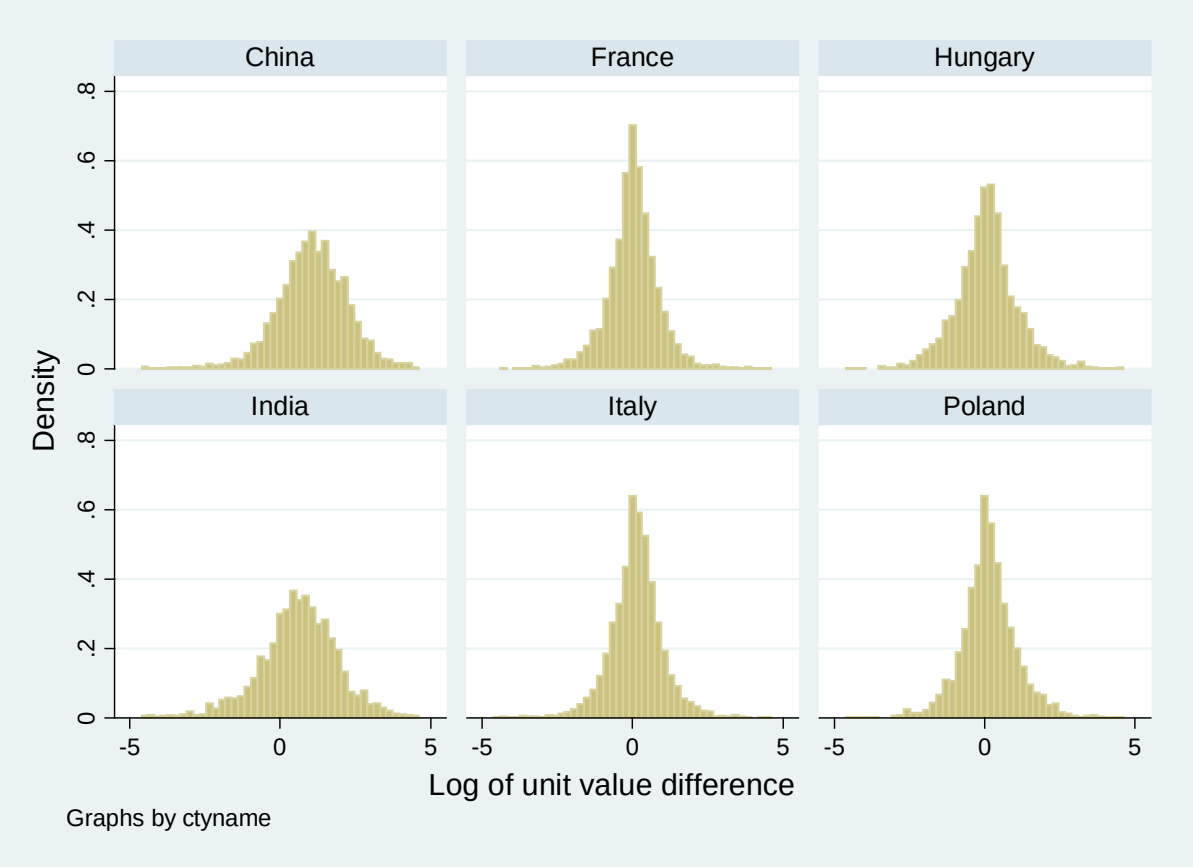
$$UVdiff = \log\left(ExUV / \mathrm{Im}UV\right)$$

where $UVdiff$ is Unit Value Difference; $ExUV$ is export unit value; $\mathrm{Im}UV$ is import unit value. Note that this index is unit free and zero represents no price difference between imports and exports.[8] We

8 We take logs of price ratios because simple ratios without taking logs will bias the distribution toward larger values. Consider three products. The export price of the first product is 1 and its import price is 1, which gives the export-import ratio of 1. For the second product, the export price is 2 while the import price is 1, giving the export-import ratio of 2.

compute Unit Value Difference for all the IIT products for a pair of countries and take distribution. Figure 16 shows the distribution for cases of Germany's IIT in 2007 with some of its partners. It is clear that in the case of Germany's IIT with France and Italy, unit price is centered around zero with a relatively high kurtosis. On the other hand, the distribution of unit price difference of Germany's IIT with China and India shows that the mean is clearly positive and kurtosis is low. The case with Poland and Hungary is between these two cases.

Figure 16: Distribution of IIT products price difference of Germany with some selected countries in year 2007



The third product has export price of 0.5 and import price of 1, yielding the export-import ratio of 0.5. When we take distribution of these three cases, 0.5 is left to the no-price-difference case of 1, while 2 is right to it. But the distances from the center of 1 are different. So, the picture gives us a wrong impression that the price difference of the second product is larger than the price difference of the third product. The difference should be the same. This occurs because the export-import ratio below 1 is confined to the set of (0, 1) while the export-import ratio above 1 take values in the set of (1, infinity). In order to address this problem, we take the natural logs, which gives 0 (no price difference) for the first product, 0.693 for the second product, -0.693 for the third product.

In the above simple analysis of unit value difference, there is neither the dimension of relative trade values nor the magnitude of the "overlap". Thus, our second measure puts some weight on the unit value difference by trade values and the magnitude of the "overlap".

Our "unit value difference measure of IIT" is computed as:

$$UVDiffMeasureofIIT_{ij} = \sum_k \left[\left\{ \log\left(\frac{ExUV_{ijk}}{\mathrm{Im}UV_{ijk}} \right) \right\} \bullet \left\{ \frac{\left(1 - \frac{\left| Ex_{ijk} - \mathrm{Im}_{ijk} \right|}{Ex_{ijk} + \mathrm{Im}_{ijk}} \right) \bullet \left(Ex_{ijk} + \mathrm{Im}_{ijk} \right)}{\sum_k \left(\left(1 - \frac{\left| Ex_{ijk} - \mathrm{Im}_{ijk} \right|}{Ex_{ijk} + \mathrm{Im}_{ijk}} \right) \bullet \left(Ex_{ijk} + \mathrm{Im}_{ijk} \right) \right)} \right\} \right] \quad (3)$$

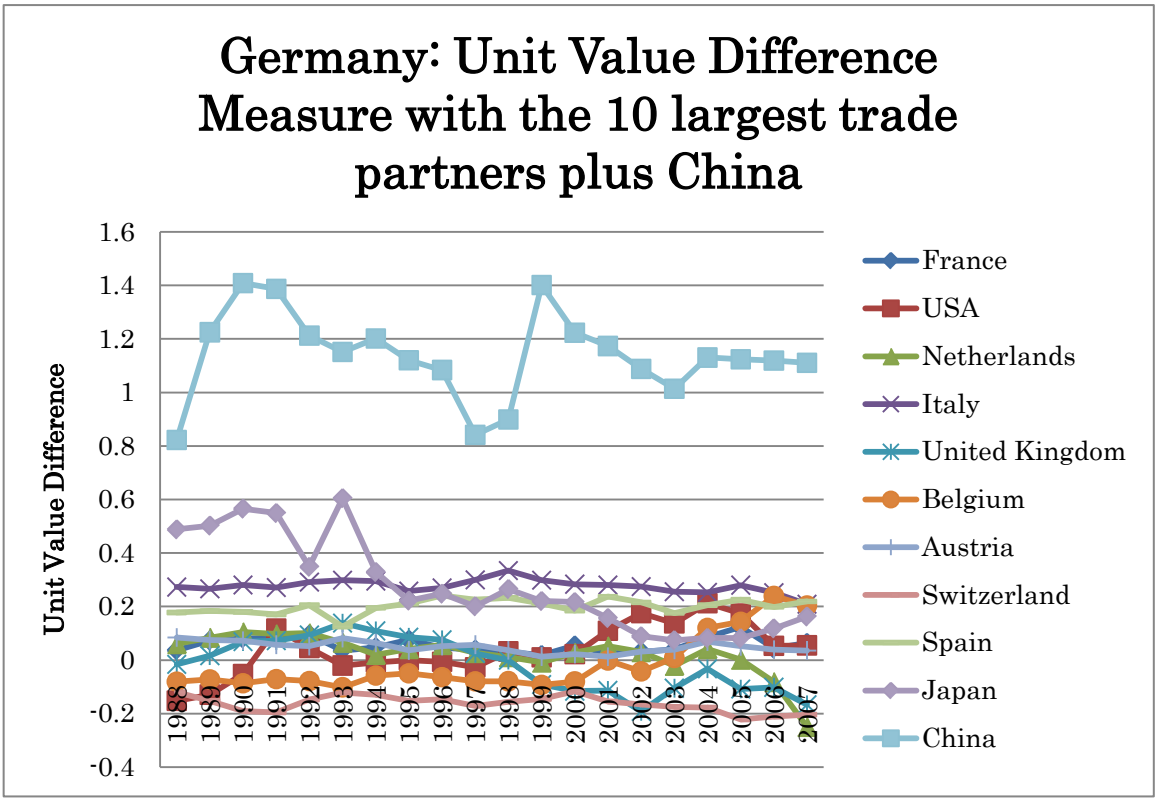
where $ExUV_{ijk}$ is Export Unit Value of IIT product k between country i and country j. Similarly for $\mathrm{Im}UV_{ijk}$. The first term in the curly bracket represents the unit value difference of product k.

The term in the second curly bracket represents the share of IIT trade value of IIT product k (the numerator) among the total IIT trade value of all IIT products (the denominator). In other words, it represents how product k's IIT trade value is imporant in total IIT trade value. For example, if the product k's IIT trade value represents an extremely high share among the total IIT trade value, say 99 percent, the unit value difference of the product k is weighted by 0.99, having an overwhelming influence to the overall unit value difference measure of country i with country j. A simple numerical example of this measure's computation is in Appendix A.3.

Figure 17 shows the unit value difference measure of IIT of Germany with its top ten partners plus China. A stark contrast between China and the other ten partner countries can be witnessed.

While the numbers of the other ten partner countries gather around zero, that of China is well above the level of the other countries. This indicates that made-in-China products are much cheaper than made-in-Germany products. This finding is in line with our priori notion. A more interesting finding is the evolution of the number of China. Contrary to recent claims of China's quality improvement, there is no clear downward trend over the last 20 years. These two findings for China are common features for the other major EU countries. As to the evolution of the unit value difference with China of the major EU countries, it even increases for the last ten years.

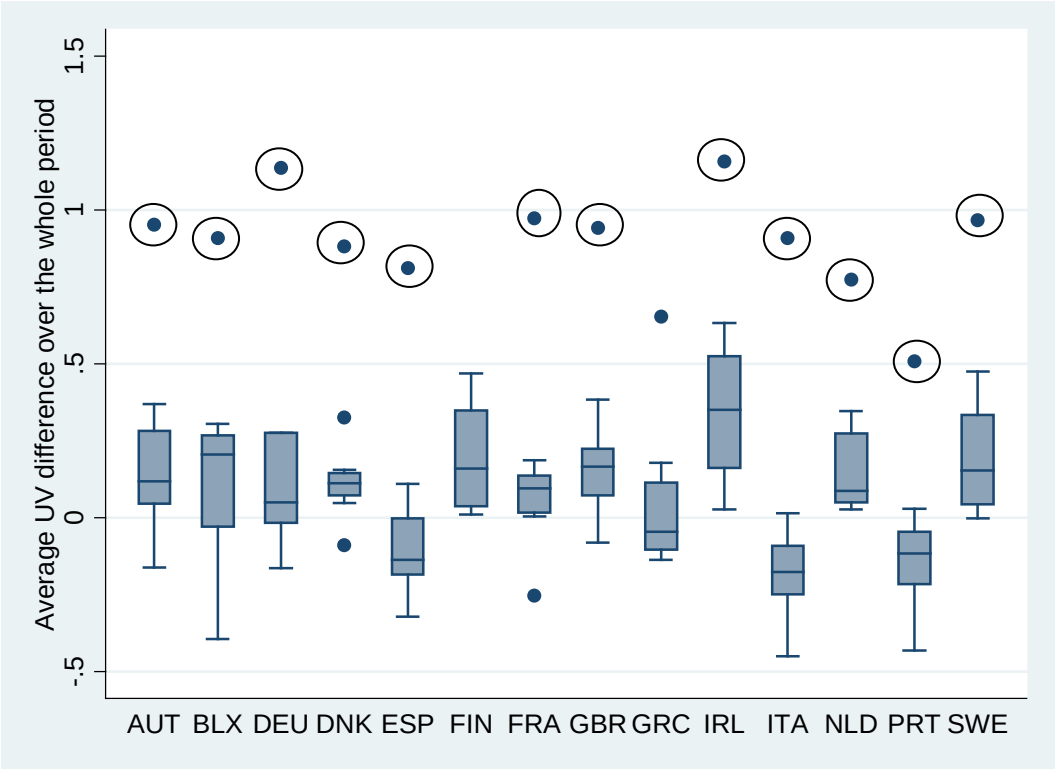
Figure 17: Germany – Unit Value Difference Measure with the 10 largest trade partners plus China



For the stark difference between China and the other 10 largest trade partners, the Box-and-whisker plot for all the EU-15 reporter countries (Figure 18) helps us to see if such is a common feature of EU-15 countries.[9] Except Finland and Greece, unit value difference measures with China are clear outliers.

Figure 18: Box-and-whisker plot of Unit value difference measure with China and other major trade partners

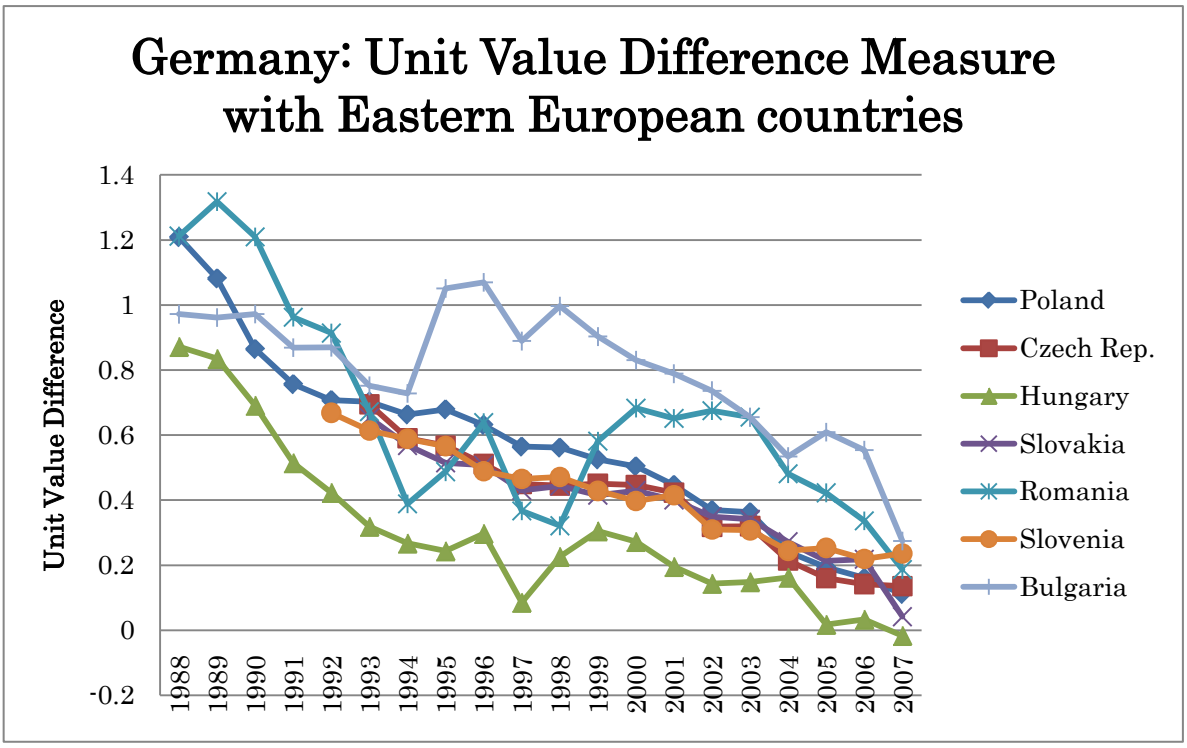
[9] The boxes cover interquartile range, from the lower quartile to the upper quartile. The whiskers, denoted by horizontal lines, extend to cover most or all the range of the data. In the box-and-whisker plot of Figure 18, we have placed the upper whisker at the upper quartile plus 1.5 times the interquartile range, or at the maximum of the data if this is smaller. Similarly, the lower whisker is the lower quartile minus 1.5 times the interquartile range, or the minimum should this be larger. A box-and-whisker plot is a very useful tool to identify outliers.



The circles indicate China.

Gemany's Unit Value Difference Measure with Eastern European countries is in Figure 19. We can see a clear decreasing toward. Poland is climbing up the quality ladder vis-à-vis Germany, which is also indicated in Section IV. However, it is worth emphasizing here that the unit price difference measure proposed in this section is free from any arbitrary choice of threshold levels and takes fully into account information of the price difference. The other major EU countries also register decreasing trend of the unit price difference measure against Eastern European countries although the case of U.K. is not so clear-cut. It is also worth emphasizing that in the year 2007, the Eastern European countries achieved the level around 0.2, which is close to the case of the other major trade partners, such as Italy, Spain, Belgium or Japan

Figure 19: Germany – Unit Value Difference Measure with Eastern European countries



For the above findings for Eastern European countries, to see if such a trend is a general phenomenon for all EU-15 reporter countries, we run the following simple regression[10].

$$UVDiffMeasureofIIT_{ij} = \beta_0 + \beta_1 t + \beta_2 \left(EastEuroDummy * t \right) + \tilde{\beta}_3 Pair + \varepsilon_{ij}$$

where $UVDiffMeasureofIIT_{ij}$ is Unit Value Difference Measure of IIT of reporter country i with partner country j; t is time variable which takes 1 (for the year 1988) to 20 (for the year 2007); $Pair$ is a vector of reporter-parter pair dummies; and $\varepsilon_{t,d}$ is an iid error.

Table 3 shows the regression result. While β_1 estimate is statistically insignificant, β_2 estimate is negative and statistically significant at 1% level. We also run the following regressions for pairs of each EU-15 country and each Eastern European country.

$$UVDiffMeasureofIIT = \beta_0 + \beta_1 t + \varepsilon$$

[10] Since our focus is not to find the determinants of Unit value difference measure but to simply see whether there is a trend over time, we do not include any other explanatory variables. (See Woodridge (2002) Ch.10 for the trend regression.)

We have counted the number of statistically significant positive coefficients and also the number of statistically significant negative coefficients for each Eastern European country. Summary is in Table 4. As the second column indicates, out of the possible maximum number of 14 (EU-15 countries; in fact 14 due to Belgium and Luxembourg as mentioned above), 10 reporter countries registers statistically significant negative coefficients with Poland. The numbers are also high for the other Eastern European countries. Moreover, the second column indicates that the cases of statistically positive coefficients are very rare. Thus, Table 2 tells us that in general Eastern European countries are reducing their unit value difference with EU-15 countries.

Table 3: Time trend regression

Regression Results: Time trend

Time (year)	-0.00117
	(-1.34)
Time (year) times Eastern Europe dummy	-0.0258***
	(-6.54)
Constant	0.215***
	(20.13)
R-squared	0.242
Number of observations	31535

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Coefficient estimates of Pair dummies are omitted.

Table 4: Summary of trend regression results for Unit value difference measure with Eastern European countries

Country name	Number of statistically significant negative coefficients	Number of statistically significant positive coefficients	Mean estimates (statistically significant estimates only)
Bulgaria	8	0	-0.037
Czech Republic	8	0	-0.031
Hungary	8	1	-0.030
Poland	10	0	-0.031
Romania	7	0	-0.048
Slovakia	5	0	-0.037
Slovenia	4	1	-0.023

VI. CONCLUSION AND POSSIBLE FUTURES WORKS

We look at EU 15 countries' IIT from several new angles, such as the evolution of the number of IIT products and the price difference measure of IIT, in addition to computing the conventional IIT index at highly disaggregated level (8 digit) for long time (20 years from 1988 to 2007). Our several new findings include notably Eastern Europe's rise in quality ladder of IIT and China's increase of low quality IIT. This paper focuses on the descriptive analysis of the IIT, putting aside the determinants of IIT. It may be an interesting study to analyse the determinants of the change of EU 15's IIT with Eastern Europe, namely the driving force of Eastern Europe's rise in quality ladder.

A.1 Details on the computation of IIT index

In the computation of Grubel-Lloyd IIT index, for the sake of consistency we delete those observations whose unit is different across partner countries or over time. Since unit price is sometimes plagued with errors and shows an extreme numbers, we delete those observations whose export price is more than 100 times higher than import price or less than 1/100th than import price.

A.2 A simple numerical example for the argument in Section III.2.

Case 1

Product	Export value	Import value	IIT index	Weight	Weighted IIT
1	60	50	0.91	0.50	0.455
2	10	100	0.18	0.50	0.091
Total	70	150		1	**0.545**

Case 2

Product	Export value	Import value	IIT index	Weight	Weighted IIT
1	600	500	0.91	0.50	0.455
2	20	200	0.18	0.10	0.018
3	20	200	0.18	0.10	0.018
4	20	200	0.18	0.10	0.018
5	20	200	0.18	0.10	0.018
6	20	200	0.18	0.10	0.018
Total	700	1500		1.00	**0.545**

As this numerical example shows, the aggregate Grubel-Lloyd index stays at 0.545 even if the number of IIT products increases.

A.3 A simple numerical example of the computation of the overall unit value difference measure

product	export value	import value	IIT index	Overlap	Weight	export unit price	import unit price	log (exp p/imp p)	
1	9000	8000	0.941	16000	0.816	1.5	2	−0.1249	−0.1020
2	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
3	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
4	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
5	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
6	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
7	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
8	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
9	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
10	200	1000	0.333	400	0.020	2	1.5	0.1249	0.0025
Total	10800	17000		19600	1.000			Summing up	**−0.079**

Product 1's Grubel-Lloyd index is computed using export value and impor value and takes the value 0.941. By mutiplying the sum of export and import value, which is 17000 in the current case, by IIT index of 0.941 gives the IIT trade value of 16000, which, in turn, is simply the overlapped value of imports and exports, i.e., 8000 times 2. The IIT value of 16000 of product 1 has the share of 0.816 (=16000/19600). Log of unit value difference of product 1 is -0.1249. This value is weighted by the

weight of 0.816. We do the same for all the other products and sum them up to come up with the overll unit value difference measure, which is -0.079 in the current case.

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