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**New Aspects of Intra-Industry trade:
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New Aspects of Intra-Industry trade: Evidence from EU-15 countries

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ABSTRACT

This paper argues about some missing aspects of intra-industry trade (IIT) and proposes some alternative measures to better capture the nature of IIT. We show the over-time evolution of the number of IIT products, and propose an index which captures the share of the number of IIT products over the number of all traded goods. We also show how arbitrary the conventional classification into Horizontal and Vertical IIT indices are, and then propose a new measure using the unit value difference of IIT products. To discuss these issues we use trade data at HS 8 digit product level of EU 15 countries for the period 1988 – 2007, mainly within EU countries as well as with Eastern European countries, and with China as major EU trading partners. Our findings include the Eastern European countries' rise up the quality ladder, and the substantially lower prices of China's exports to EU 15 countries vis-à-vis China's imports from them, whose gap is not narrowing even in very recent years.

JEL H32, P16.

Keywords: Intra-industry trade, Horizontal and Vertical Product Differentiation, Quality, unit price gap

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I. INTRODUCTION

It is widely documented that the volume of intra-industry trade (IIT) (i.e. two-way trade within a sector or a product) expanded dramatically with the worldwide trade liberalisation, especially in the past few decades, although inter-industry trade, (i.e. one-way trade) is still substantial. The last few decades saw many empirical studies on IIT, both in its measurement and determinant factors. In particular, the recent IIT literature has shed light on product level analysis and prices at minute product level because 1) many developing countries have joined the world trade system, with substantial variation in the price of particular IIT products across countries (increased import-export price gap within a product) and 2) more varieties of products with various unit prices and quality within one product category can be exported with each other due to a fall in trade costs (increased number of IIT products). To shed light on the first issue, that of price differences of IIT products, many IIT studies classify conventional IIT into two types, i.e. horizontal IIT (HIIT) and vertical IIT (VIIT). HIIT is defined as IIT without a substantial per-unit export and import price gap, while VIIT is defined as IIT with a substantial per-unit export and import price gap. However, the existing IIT literature has not paid much attention to the second issue concerning the increase in the number of IIT products.

The EU trade data have a unique virtue compared with those of other countries. First, they are available at highly disaggregated level of HS 8 digit, which is consistent across all EU member countries. Second, and more importantly, the HS 8 digit code of the EU trade data are consistent for exports and imports, which allows us to compare the unit price of exports and imports of particular HS 8 digit products. This is not the case for other countries such as the US or Japan. Thus, our paper analyses the nature of IIT for EU-15 countries' trade. In particular, it is worthwhile to study the nature of EU 15 countries' IIT with China and with 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 world trade and becomes the number one trade partner of EU, but also how the number of IIT products has changed over time. Moreover, the evolution of export-import price differences 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.

This paper attempts to see the nature of IIT from different angles through existing lenses, and through new lenses we propose. By so doing, we display several stylised facts concerning the nature of EU 15 countries' IIT. Our contributions to the literature are three-fold. First, our paper provides some evidence on a drastic evolution in the *number* of IIT products, a feature not investigated so far

in the literature. Second, it shows how arbitrary the export-import unit price gap threshold values used to classify HIIT and VIIT indices are, and then proposes some alternative measures of quality difference of IIT that do not require the setting of any threshold values. These measures allow us to see the nature of IIT from different angles. Third, this paper provides an almost comprehensive picture of the evolution of the Grubel-Lloyd index over 20 years (1988-2007) for the top 30 trade partners of each EU 15 country at HS 8 digit product level, which as far as we know, is one of the largest and longest samples in the literature as discussed below.

Our analysis yields several findings. First, the 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 number of IIT products of EU 15 countries with Eastern European countries is generally in upward trend, except Germany for whom the number of IIT products stays almost constant after the middle 1990s. A dramatic increase in the number of IIT products of EU 15 countries with China is documented. Third, China's IIT with the EU 15 is generally characterised by IIT in which the unit price of China's exports to the EU 15 are lower than the unit price of China's imports from the EU 15. Moreover, this price gap is not in decreasing trend, even in recent years. This finding indicates that while China has rapidly expanded its range of export products, and its spectrum of export products are now closer to that of developed countries, as documented by Rodrik (2006) and Schott (2008), there is still a large gap in unit prices and the gap is not narrowing. Fourth, a clearly increasing trend of 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 VIIT between EU 15 and Eastern European countries, but this paper shows the ratio is clearly decreasing. Moreover, it shows a clearly decreasing unit price gap in the major EU countries' IIT with the Eastern European countries. This finding implies that Eastern European countries climb up the "quality ladder".

Literature and Our Paper

Greenaway, Hine, and Milner (1995) (hereinafter GHM) 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 GHM involves cross-country analysis without any time dimension, Aturupane 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 foreign direct investment (FDI) related trade. It shows that, in Asia, VIIT is

fairly dominant, which is mainly driven by Japanese 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 a longer period and analyses at a 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 as our paper, their analysis shows an increase in 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 between *pairs* of countries. Milgram-Baleix and Moro-Egido (2010) focuses on Spain's VIIT. Improving on the previous literature in its data construction and estimation techniques, it analyses the determinants of Spain's VIIT with developed and developing countries at HS 8-digit level. Apart from the determinants of VIIT, it shows that Spain is exporting low quality goods not only to high income European countries, but also to developing countries. Whereas all the above papers are focused 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 a more disaggregated level, an important element for the analysis on the quality difference of products. In terms of its comprehensive treatment, Brühlhart (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 substantially differs from his in that we show the evolution in the number of IIT products and the quality difference of IIT (unit export-import price gap), and also in that we conduct the analysis at a more disaggregated level. The closest paper in terms of an attempt at gauging unit value difference of IIT is Azhar and Elliott (2006). While Azhar and Elliott (2006) is the first such attempt, we propose a different method, which we argue is superior.

Plan of paper

The rest of the paper is organised as follows. The next section explains the data and the 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 the HIIT and VIIT index with various threshold levels, pointing out the 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.

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 (2007) shows that Japan's IIT with non-OECD countries, especially Asian countries, are driven by technology transfer by Japanese FDI firms.

II. DATA AND GRUBEL-LLOYD IIT INDEX

We use Eurostat trade data, which cover exports and imports of EU countries at 8 digit HS code with the maximum period of 20 years, from 1988 to 2007. There are 17,249 HS 8-digit codes in total.² Since our focus is IIT and its unit price difference, we confine our analysis to the manufacturing sector. 13,173 HS 8-digit codes correspond to the manufacturing sector. Although a great advance in the study of IIT has been achieved by our 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 the Grubel-Lloyd (GL) index and its variants, the HIIT index and the VIIT index.

The well-known classical GL index of product category k is defined as:

$$IITindex_k = 1 - \frac{|Ex_k - Im_k|}{Ex_k + Im_k}$$

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.

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 weight by the share of trade values. We compute the GL index of each EU 15 country with each country's top 30 trade partners in the world. The GL index between country i and country j is defined as above, namely:

$$IITindex_{ij} = \sum_{k=1}^K \left(\left(\frac{Ex_{ijk} + Im_{ijk}}{\sum_k (Ex_{ijk} + Im_{ijk})} \right) \left(1 - \frac{|Ex_{ijk} - Im_{ijk}|}{Ex_{ijk} + Im_{ijk}} \right) \right) \quad (1)$$

Using (1), Figure 1 and Figure 2 show the evolution of the GL IIT index of Germany and France with their 10 largest trade partners plus China.³ We show the cases of Germany and France as representative countries and spare showing the other EU 15 countries' case due to space constraint. For all the other EU 15 countries' cases see the addendum of this paper, which is prepared as a separate file. The IIT indices with their largest trade partners are in the range of 0.4 - 0.5 and stay

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.

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

almost at the same level over time. The IIT indices with China are much lower than the other partner countries in the top 10. It was around 0.1 at the starting year 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.)

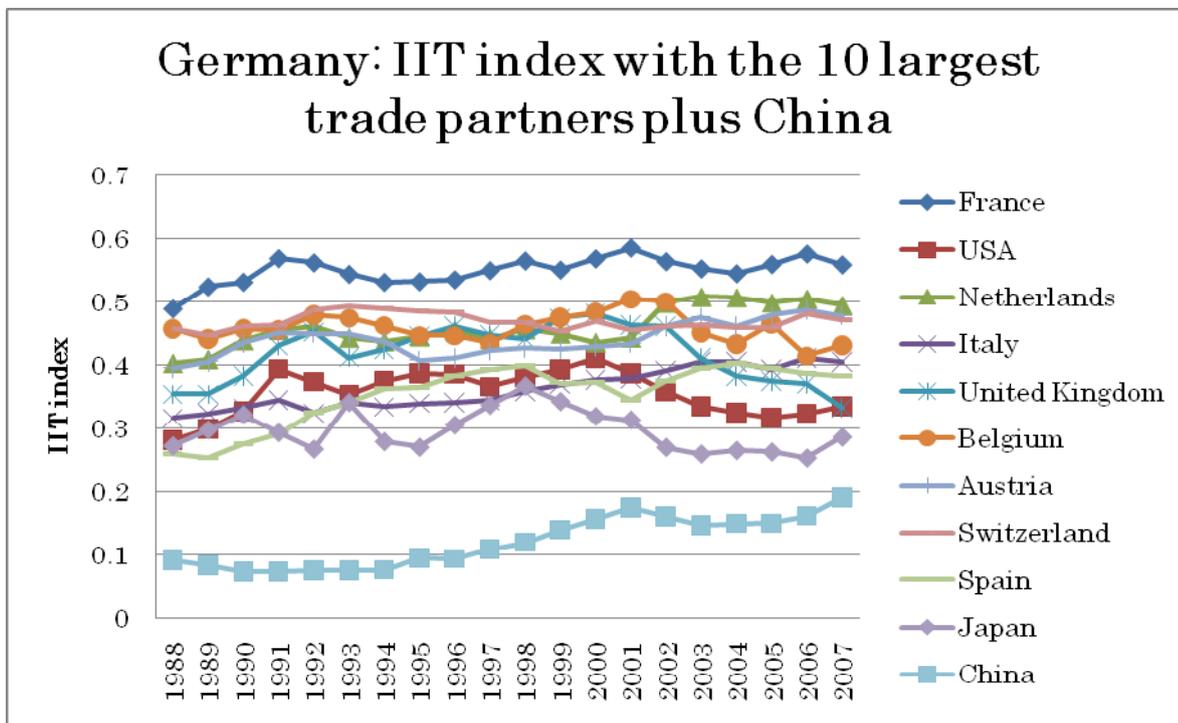
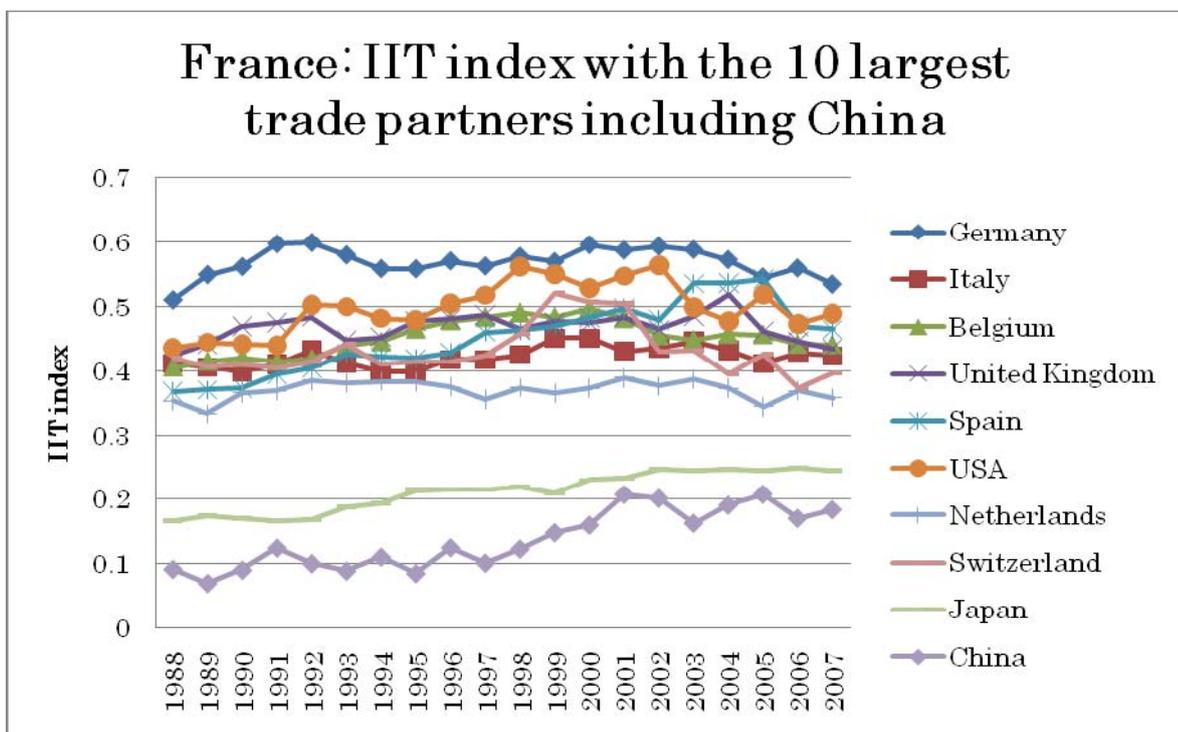
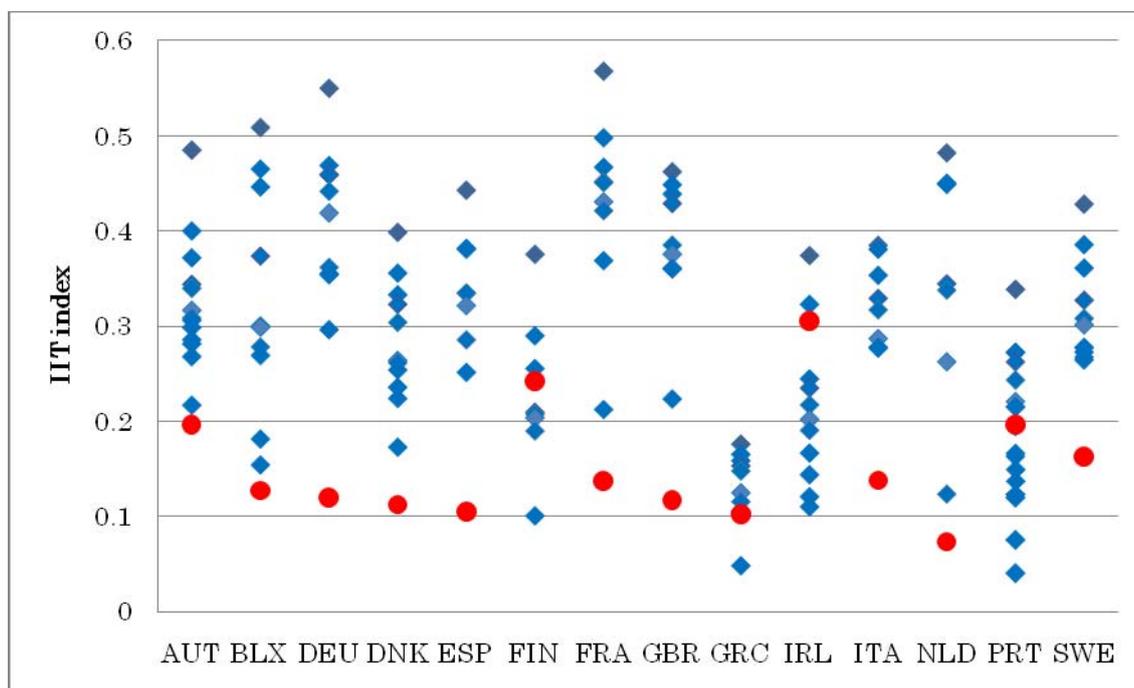


Figure 2: France - IIT index with the 10 largest trade partners including China



To see if the above finding of a 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 largest trade partners including China⁴. The red round dots represent the 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 countries⁵, China registers the lowest IIT index. Moreover, in Germany, Spain, France, the United Kingdom, Italy, the 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



The other partner group we have chosen for analysis is the Eastern European countries⁶. Figure 4 and Figure 5 show the IIT index with Eastern European countries of Germany and France, respectively. We notice that the IIT index of Germany with Eastern European countries exhibits an increasing trend while that of France shows no particular trend. An increasing trend found in Germany is not

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.

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

discerned in the other EU 15 countries either. Another interesting finding is that the 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 major EU trade partners (e.g. with France, the Netherlands or Belgium) we have seen in Figure 1. Almost the same is true for French IIT with Eastern European countries (Figure 5).

Figure 4: Germany - IIT index with Eastern European countries

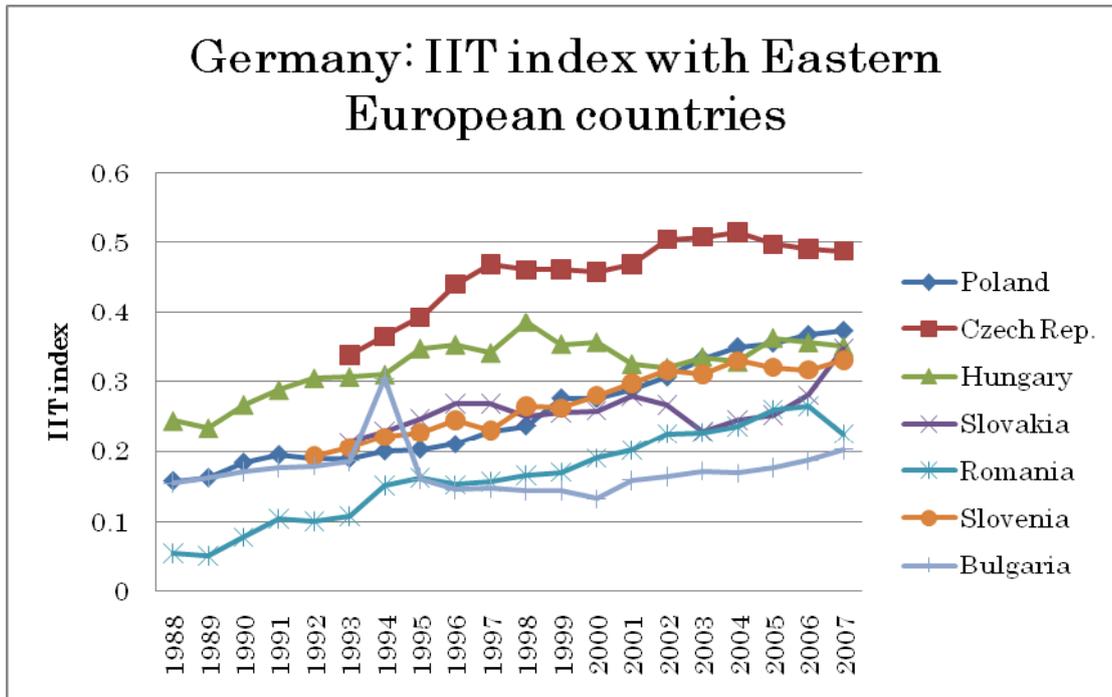
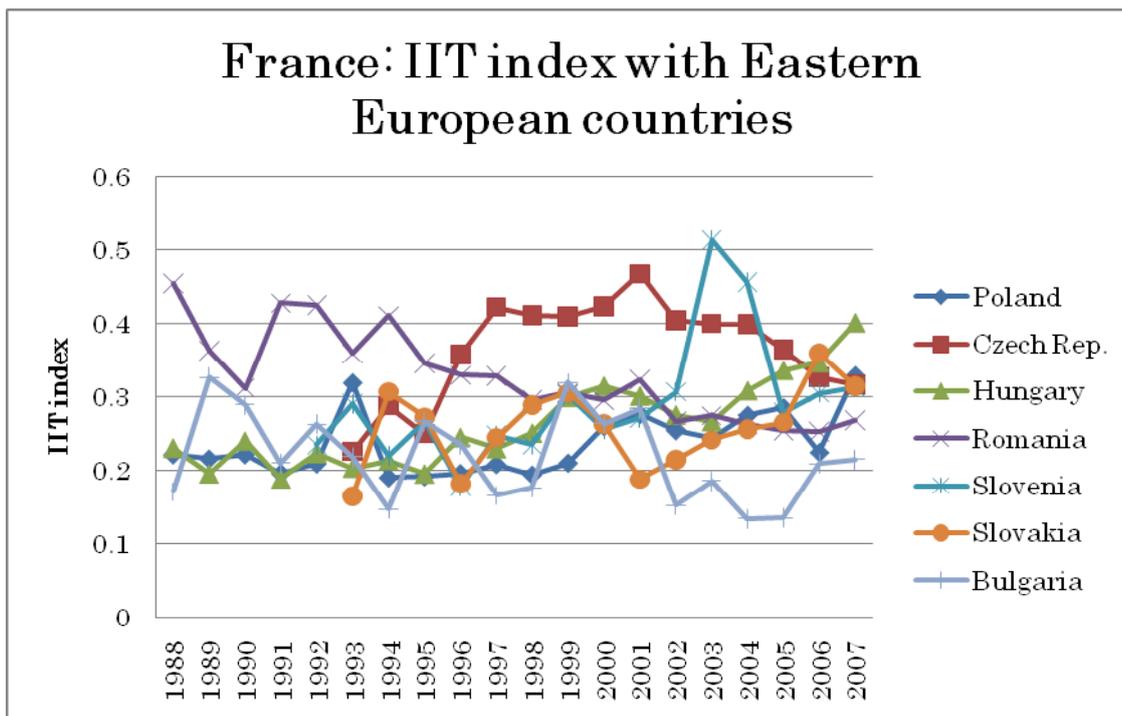


Figure 5: France - IIT index with Eastern European countries



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

The IIT literature starting from Grubel and Lloyd (1975) is based on the new trade theory of Krugman (1980) where all varieties are traded. Thus, intra-industry trade of new products has not been in scope, and thus has not been studied so far to the best of our knowledge. “New new” trade theory, or the heterogeneous firms trade model by Melitz (2003), on the other hand, explains changes of traded varieties. In the spirit of the heterogeneous firms trade model, we show how the number of IIT products has evolved.

In fact, although the GL 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 the GL IIT index between countries i and j is each product's IIT index and its share in total trade value. For example, suppose that there are only two goods. The GL index of one good is 0.2 and its trade share (weight) is 0.5. The GL index of the other good is 0.8 and its trade share (weight) is 0.5. Then, the aggregate GL index is 0.5 ($=0.2 \times 0.5 + 0.8 \times 0.5$). Suppose the number of IIT products has increased to six. Assume further that the GL 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 GL index stays the same ($0.2 \times 0.5 + 0.8 \times 0.1 \times 5 = 0.5$) 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 the existing GL 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 their 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 another dimension of IIT, which the conventional GL-index alone does not show. While the 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 in the number of IIT products with China is a common phenomenon for all EU 15 countries.

Figure 6: Germany – Number of IIT products with the 10 largest trade partners plus China (ranked 11th)

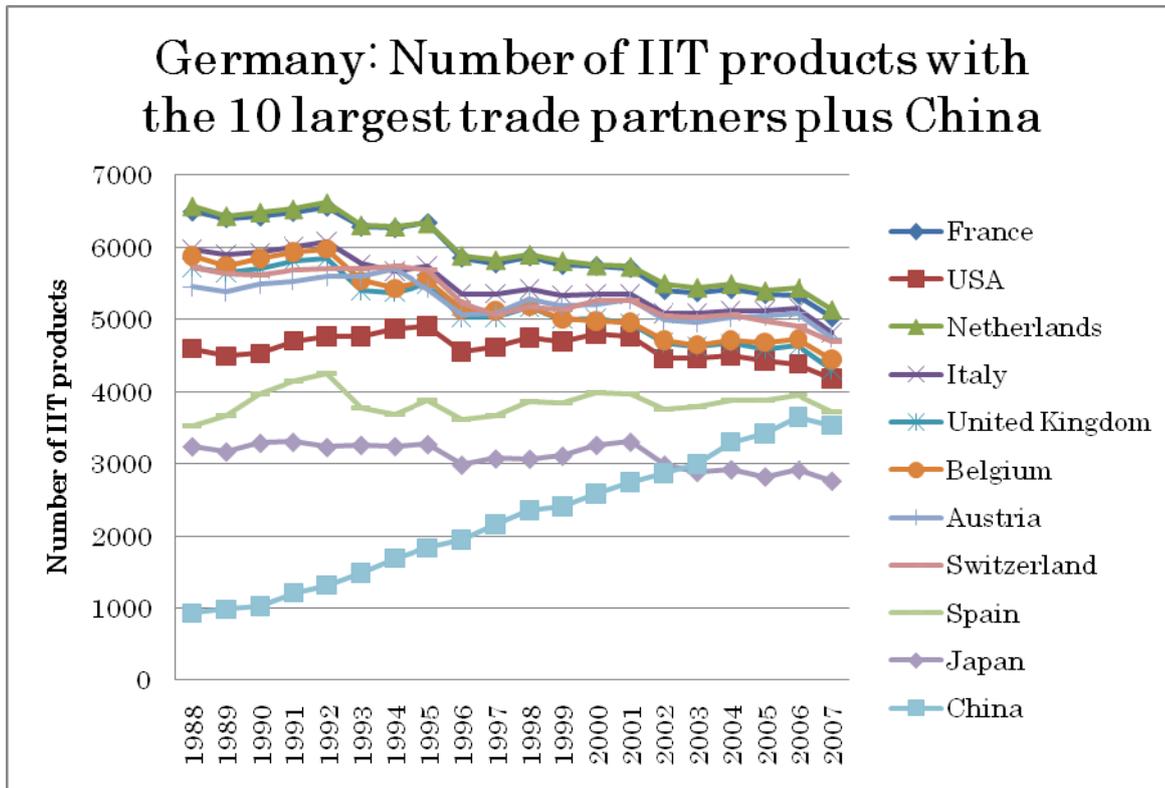
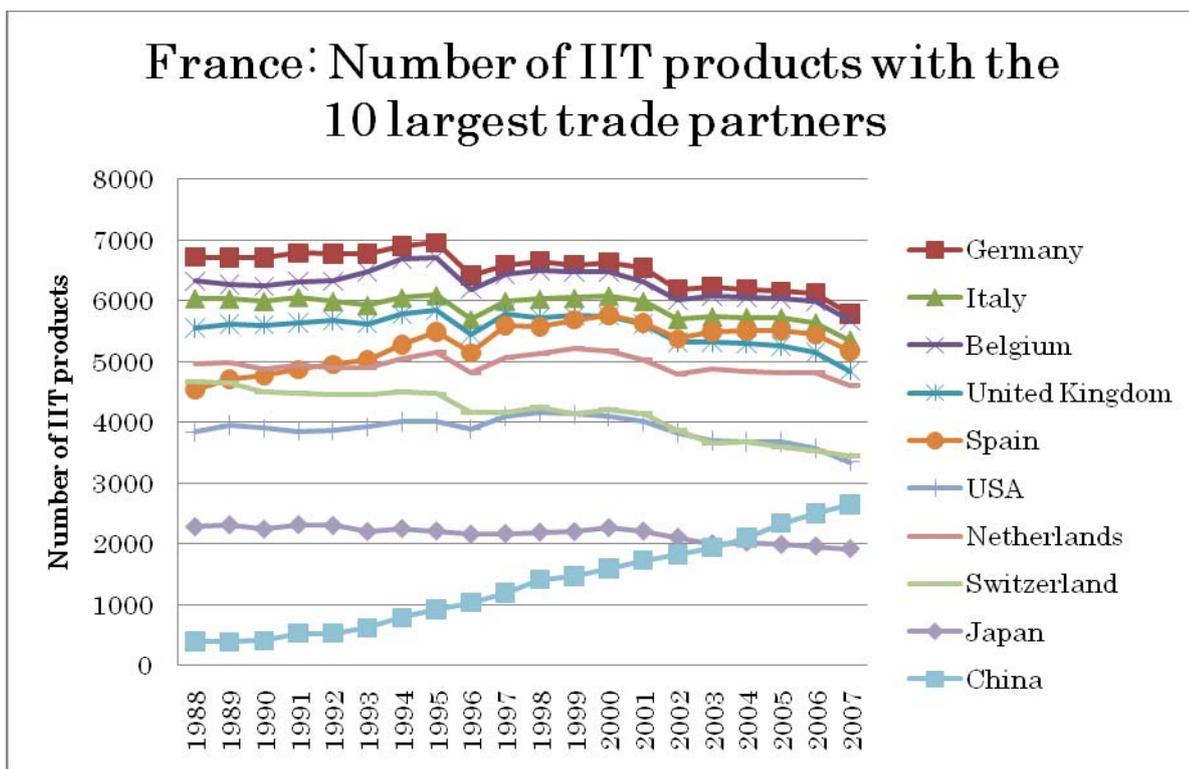


Figure 7: France – Number of IIT products with the 10 largest trade partners including China (ranked 10th)



The cases with the Eastern European countries are presented 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 number of IIT products of France with Eastern European countries shows a 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 in the number of IIT products with the Eastern European countries.

Above we argued about the evolution (*change*) in the number of IIT products. When we look at the *levels* of the number of IIT products, there is also 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 already substantially higher than those of the other major EU countries at an 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 the GL IIT index we have seen above in Section III-1. Namely, the GL IIT index of Germany with Eastern European countries exhibits an increasing trend, while those of the other three major EU countries do not. As a possible explanation for this coincidence, we conjecture 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 indices (i.e., the overlapped parts of exports and imports are not yet high), whereas Germany's IIT with Eastern European countries has already been well established by the middle of 1990s and reached the stage of large trade values and large individual (product level) IIT indices.

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

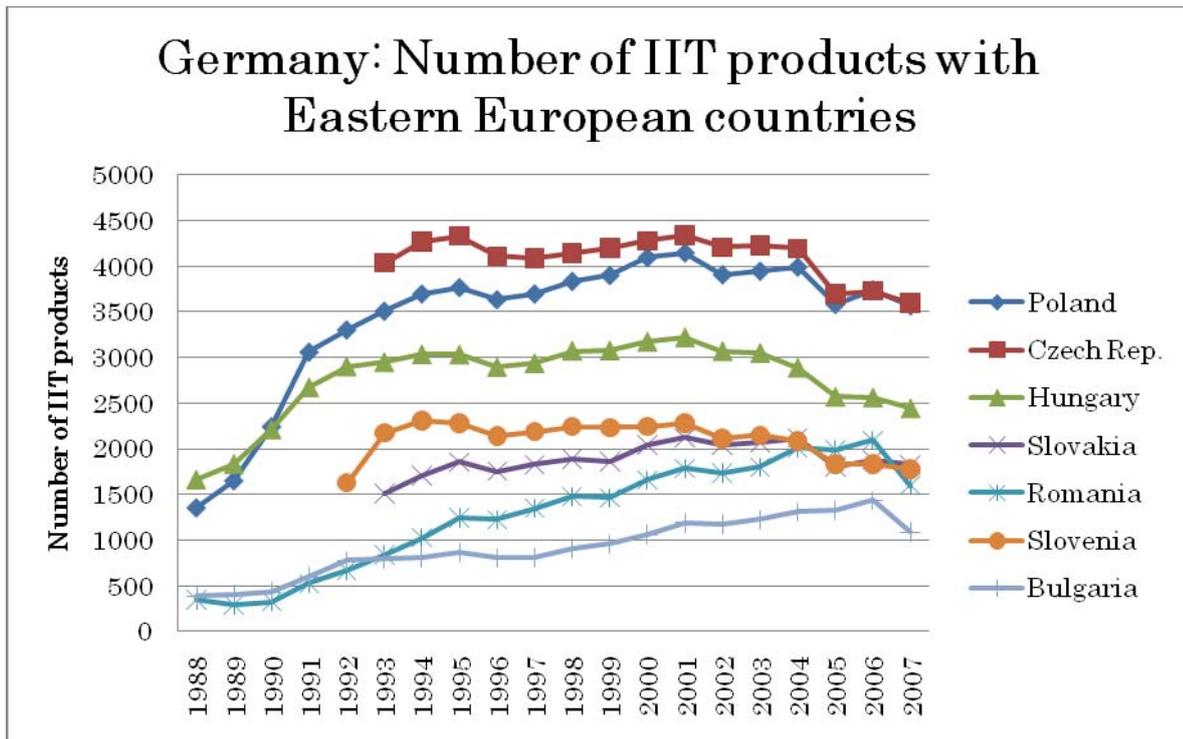
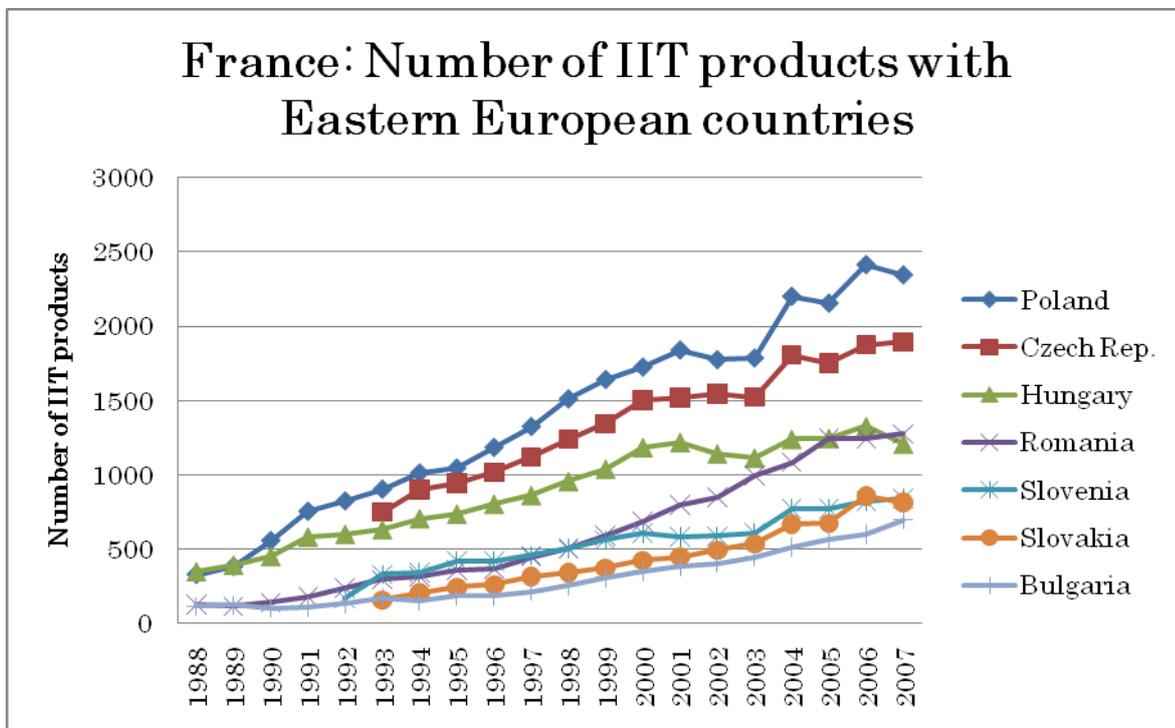


Figure 9: France – Number of IIT products with Eastern European countries



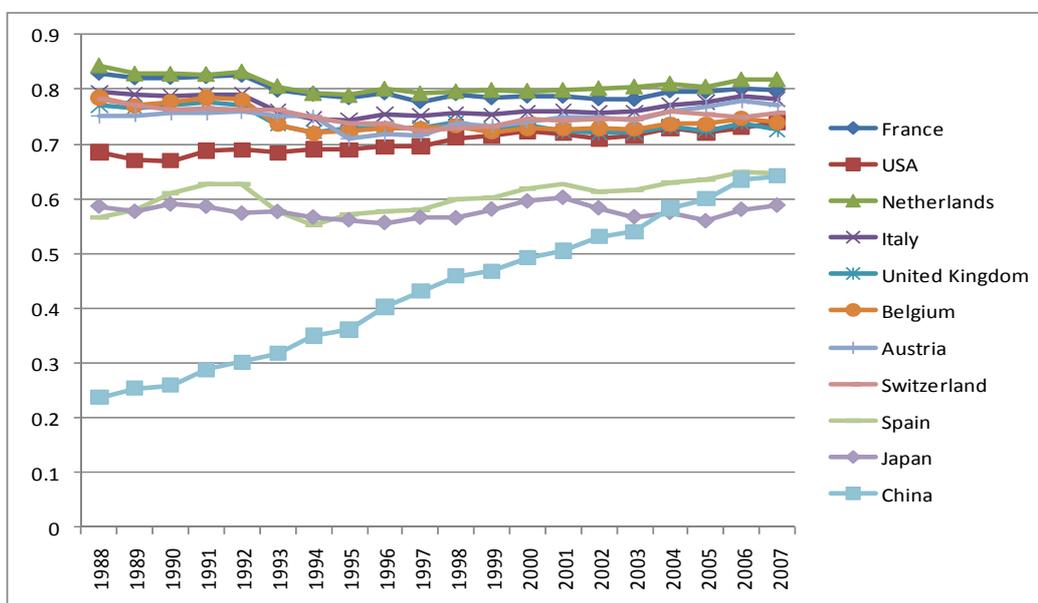
III.3. Extensive IIT index⁷

In the sub-section III.2., the absolute number of IIT products are shown. However, the number of products in one-way trade might also be changing at the same time. For example, while the absolute number of IIT products of France with Poland exhibits a rapid increase as we have seen above, the number of traded products of France with Poland in either way (i.e., exports only or imports only) may also have greatly increased. Thus, taking ratios of the number of IIT products over the total number of traded products gives us an idea of shares. We call this “Extensive IIT index” and define as:

$$ExtensiveIITindex_{ij} = \frac{NumberofIITproducts_{ij}}{NumberofIITproducts_{ij} + NumberofExportsOnly_{ij} + NumberofImportsOnly_{ij}}$$

While the Grubel-Lloyd index captures the shares of IIT *values*, the extensive IIT index we propose here represents the shares of IIT product *numbers*. Thus, the extensive IIT index complements the Grubel-Lloyd index. As Figure 10 to Figure 13 show, the extensive IIT index show similar pictures with the number of IIT products we have seen above. China and the Eastern European countries have increased not only the number of IIT products, but also the share of the number of IIT products represented by the extensive IIT index.

Figure 10: Germany – Extensive IIT index with the 10 largest trade partners plus China (ranked 11th)



⁷ We thank Richard E. Baldwin for suggesting us this index.

Figure 11: France – Extensive IIT index with the 10 largest trade partners including China (ranked 10th)

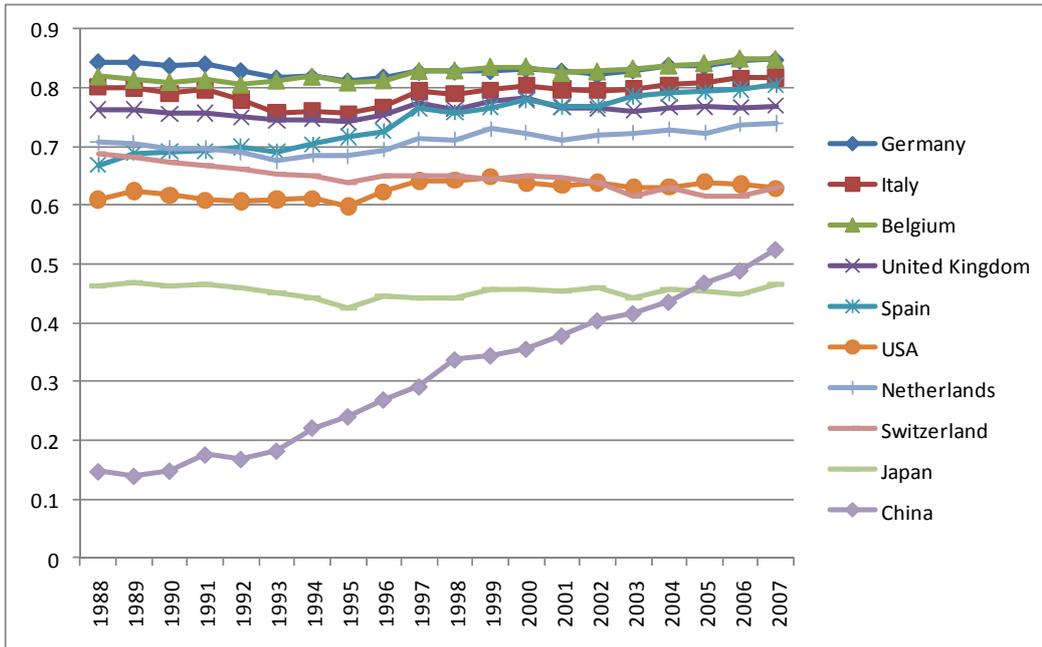


Figure 12: Germany - Extensive IIT index with Eastern European countries

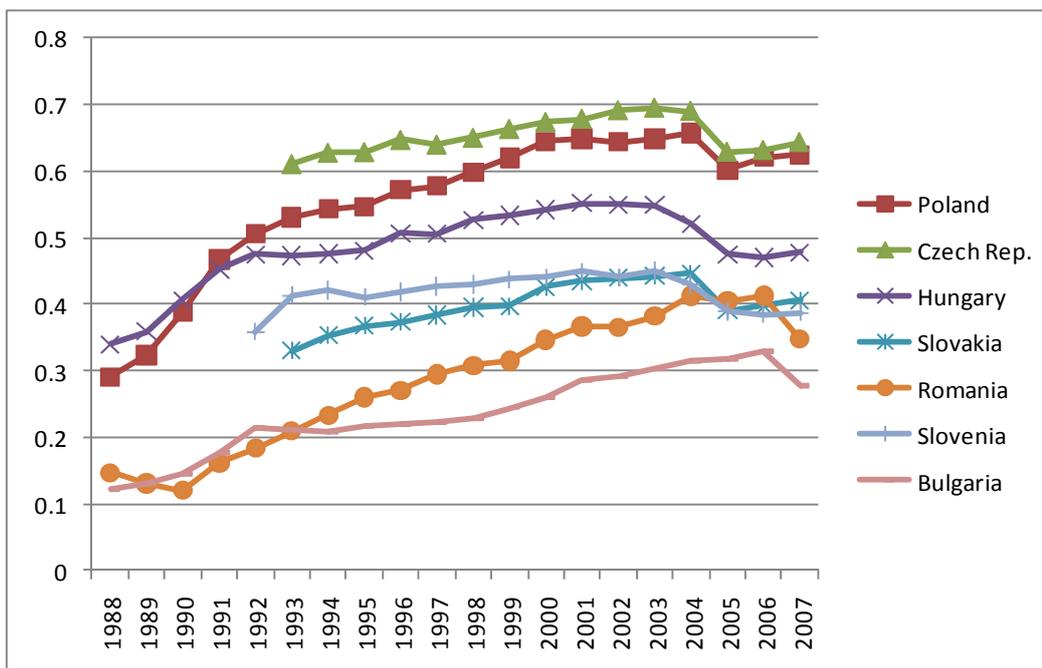
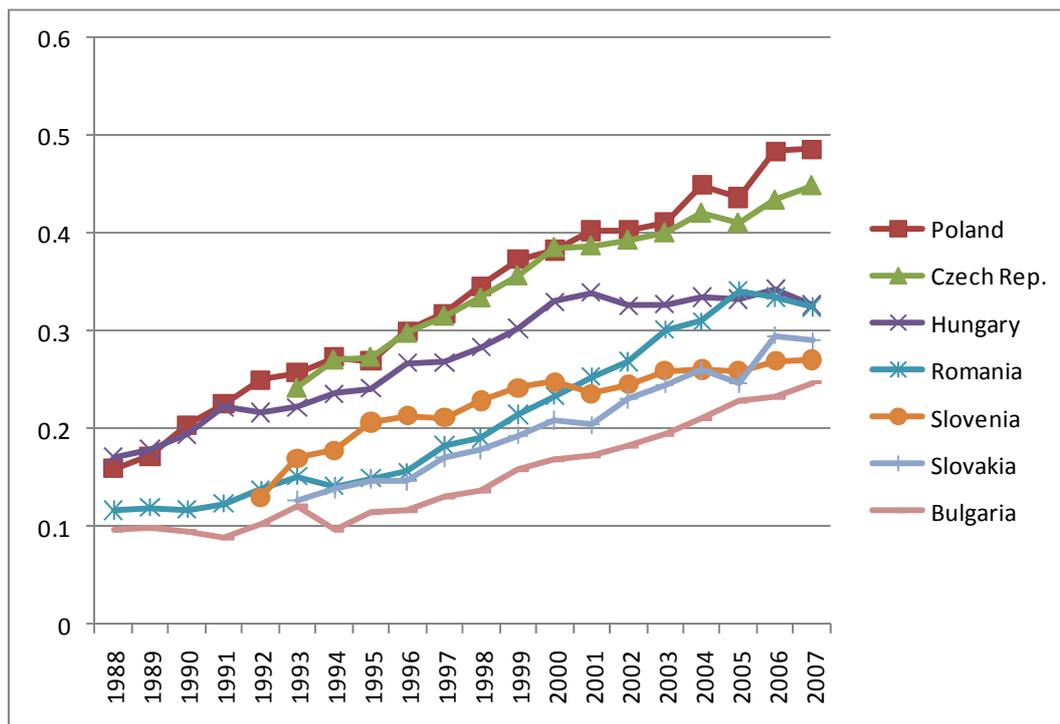


Figure 13: France - Extensive IIT index with Eastern European countries



IV. HORIZONTAL AND VERTICAL IIT INDEX

Following the existing literature, pioneered by GHM, we decompose IIT into 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 $\frac{1}{1+x} < \frac{Export\ Price_k}{Im\ port\ Price_k} < 1+x$ and VIIT is satisfied with

$$\frac{Export\ Price_k}{Im\ port\ Price_k} < \frac{1}{1+x} \text{ or } \frac{Export\ Price_k}{Im\ port\ Price_k} > 1+x. \text{ Here we adopt the lower threshold of } \frac{1}{1+x}$$

proposed by Fontagné and Freudenberg (1997) (hereafter FF) instead of $1-x$ proposed by GHM.⁸

⁸ Greenaway et al. (1995). proposes the following criterion. $\frac{1-x < \frac{Export\ Price_k}{Im\ port\ Price_k} < 1+x}{\frac{Export\ Price_k}{Im\ port\ Price_k} < 1-x \text{ or } \frac{Export\ Price_k}{Im\ port\ Price_k} > 1+x}$ for HIIT and for VIIT.

Fontagné and Freudenberg (1997) points out a problem of this threshold condition. It argues that the lower threshold of $1-x$ is incoherent with the upper threshold of $1+x$ and the problem gets worse as the threshold level gets larger. It explains: For example, the threshold of 25% means that export unit values can be 1.25 times higher than those for imports to fulfil the similarity condition. The lower limit in that case is 0.75: imports unit values need to represent at least 75% of export unit values. But this last statement can be formulated in a different way: export unit values can be 1.33 (1/0.75) times higher than import unit values, a condition which is incompatible with the condition on the right. Thus, instead of $1-x$, Fontagné and Freudenberg (1997) proposes to use $\frac{1}{1+x}$.

We compute the HIIT and VIIT index at various threshold levels, 5 percent ($x=0.05$), 10 percent ($x=0.1$), 15 percent ($x=0.15$), ...50 percent ($x=0.5$). GHM proposes sorting k 's product into a Horizontal category and a Vertical category using several threshold levels, such as 15 percent or 25 percent. In symbols, GHM decomposes the GL index of equation (1) into the HIIT index and the VIIT index:

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

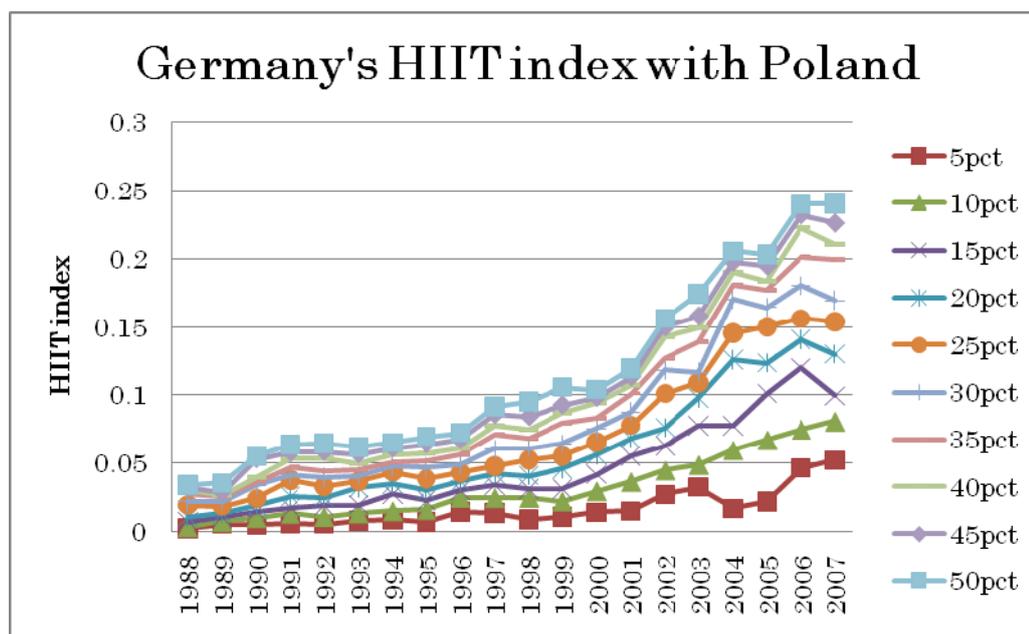
$$\underbrace{\sum_{h=1}^H \left(\left(\frac{Ex_{ijh} + Im_{ijh}}{\sum_h (Ex_{ijh} + Im_{ijh})} \right) \left(1 - \frac{|Ex_{ijh} - Im_{ijh}|}{Ex_{ijh} + Im_{ijh}} \right) \right)}_{\text{HIIT index}} + \underbrace{\sum_{v=1}^V \left(\left(\frac{Ex_{ijv} + Im_{ijv}}{\sum_v (Ex_{ijv} + Im_{ijv})} \right)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

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

The previous literature mainly uses threshold level of 15 percent, while other papers, such as Fukao et al. (2003), use 25 percent. However, there are no firm reasons and no theoretical support for the choice of these threshold levels.⁹ GHM allege that their result is robust to 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, and the *marginal* effect of the determinants, not the levels of HIIT and VIIT. However, once we choose two fairly different threshold levels, such as 10 percent and 40 percent, the choice of threshold seems to matter. For example, looking at Figure 14 showing Germany's HIIT index with Poland, we notice that the larger the threshold levels, the larger the growth rate of the HIIT index. Moreover, when our focus is on the *levels* of HIIT and VIIT, threshold levels matter greatly. In fact, Figure 14 shows that, in the year 2007, the 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 take a look at the change in 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 differs substantially depending on the chosen threshold levels.

Our paper adopts this.

⁹ 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.

Figure 14: Germany's HIIT index with Poland

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 15 and Figure 16 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. Especially, the evolution of the upper side VIIT (Figure 15) shows that, while the index in the year 2007 is higher than that in the year 1988 if we take lower threshold levels, the opposite is true if we take higher threshold levels. These findings indicate that the choice of threshold levels gives different pictures of the evolution of the IIT index.

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 at least take a look at results with various threshold levels. Although we spare showing the cases of France in this text due to space constraint, similar pictures arise for other EU 15 countries.

Figure 15: Germany's Upper side VIIT with Poland

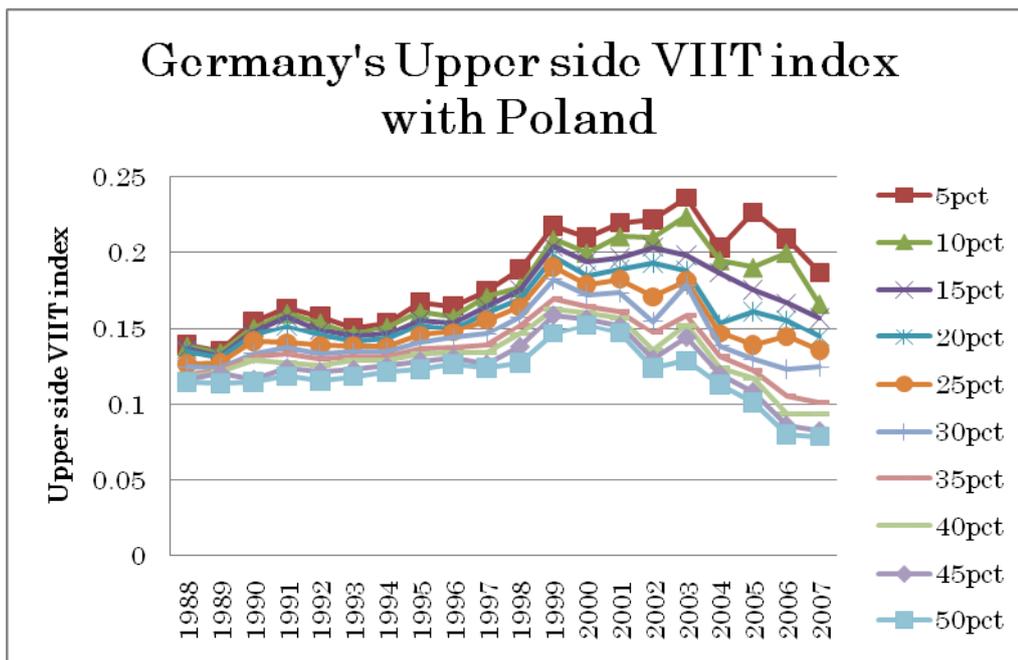
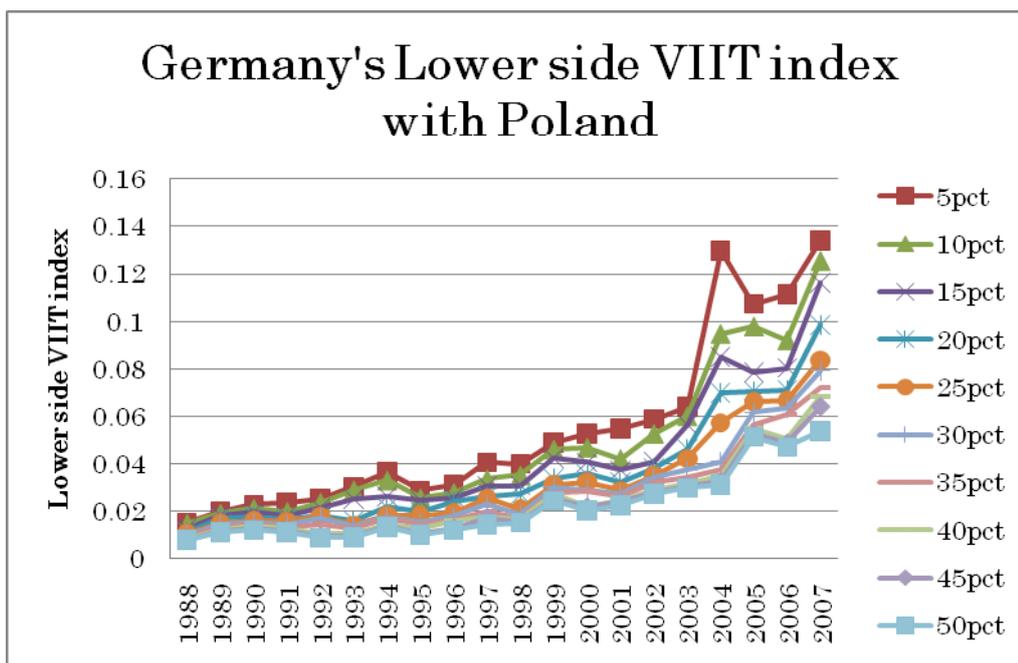


Figure 16: Germany's Lower side VIIT index with Poland



By looking at HIIT, the upper side VIIT and the lower side VIIT at various threshold levels in Figure 14, Figure 15 and Figure 16, together with the 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 three elements: the increase in the HIIT index number (Figure 14), the increase in the lower side VIIT index number (Figure 16), and the decrease in the upper side VIIT index number after around 2003 (Figure 15). This indicates that Poland improved its product quality vis-à-vis Germany.

Turning our attention to the case of trade with China, Germany's IIT index gradually increases (Figure 1). This increase can be decomposed into a slight increase in the HIIT index (Figure 17), a clear increase in the upper side VIIT index (Figure 18) and no particular trend in the lower side VIIT index (Figure 19). These findings indicate that the increase in China's IIT with Germany is characterised by an expansion of lower quality IIT products.

Figure 17: Germany's HIIT index with China

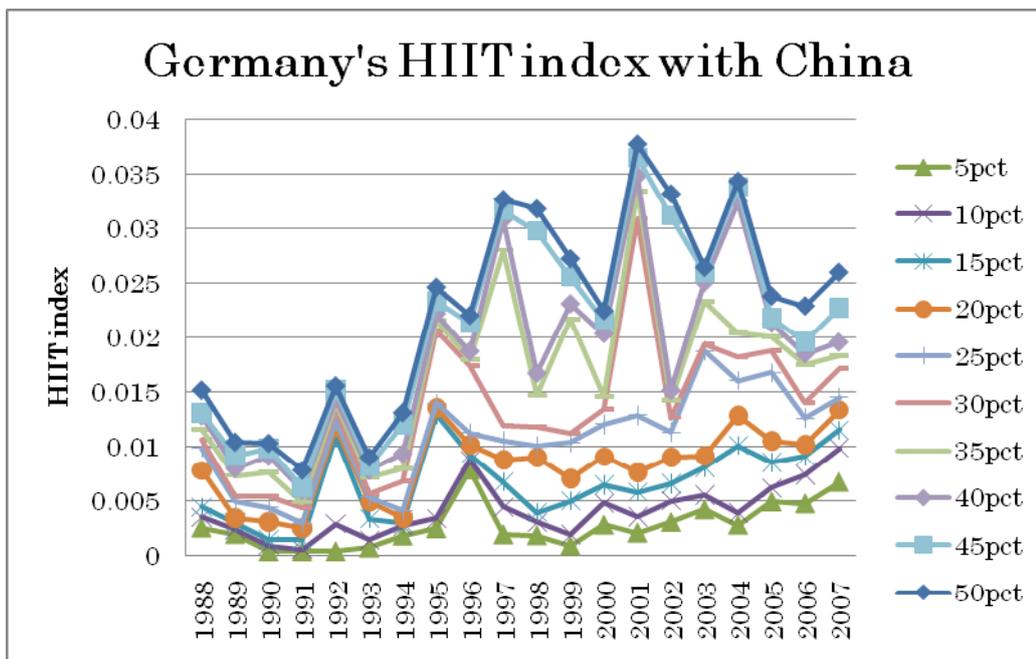


Figure 18: Germany's Upper side VIIT index with China

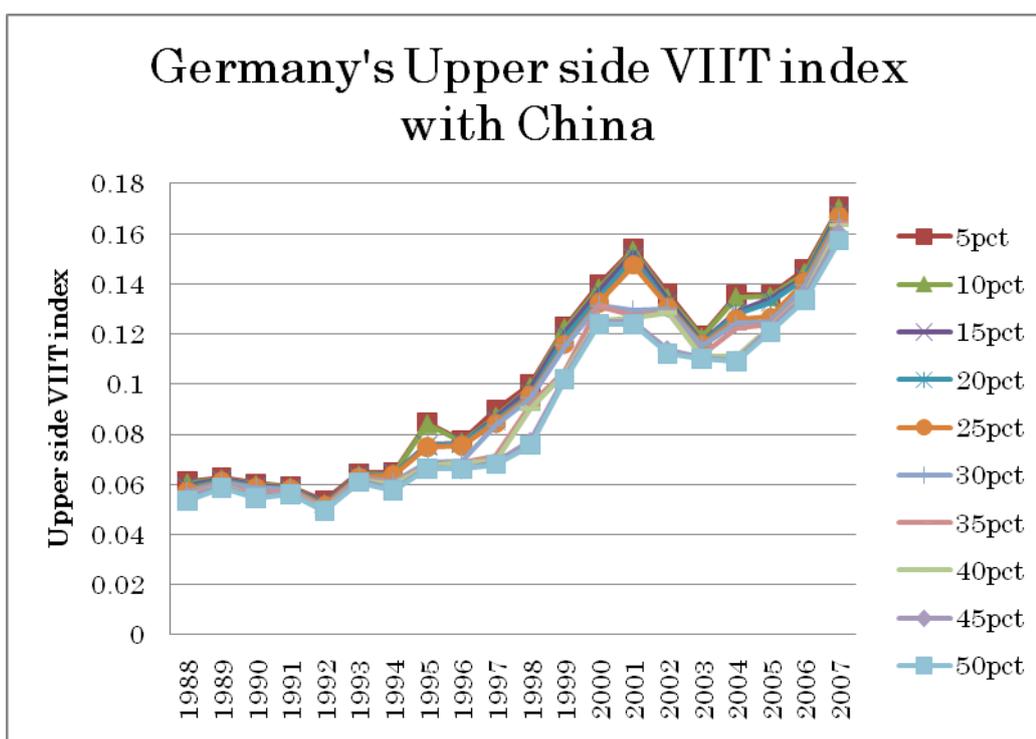
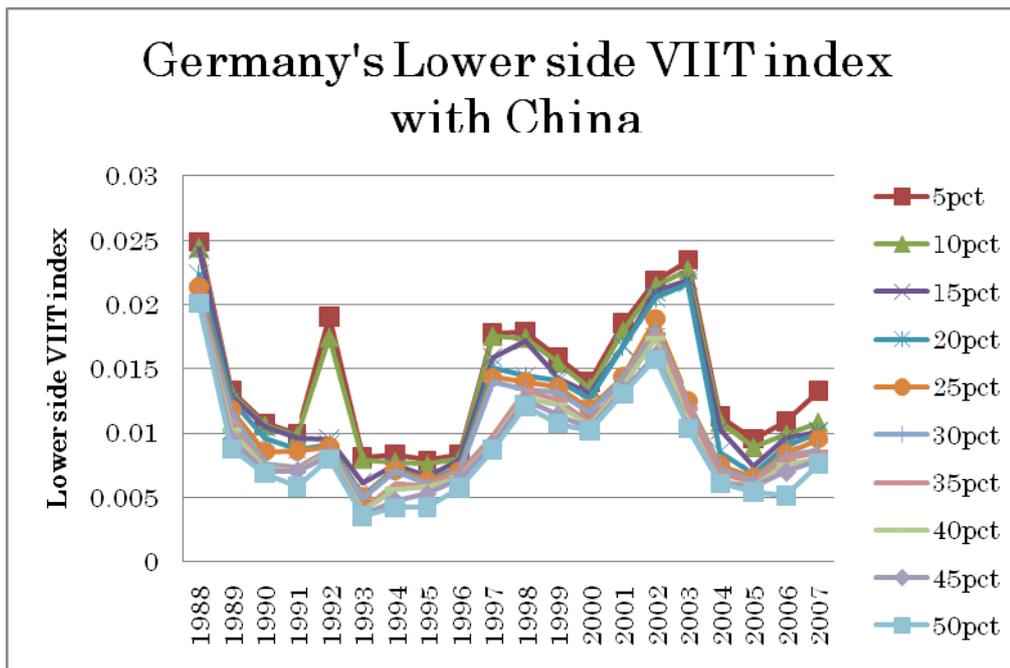


Figure 19: Germany's Lower side VIIT index with China

V. QUALITY DIFFERENCE AND IIT INDEX

One interesting issue we can extract from IIT data is how a pair of countries' trade is characterised by the difference in product quality. HIIT and VIIT indices include a feature of price difference but the focus is the same as the original IIT, namely, it represents the *share* of "overlap" of exports and imports. Information on price difference is used only for binary categorisation into HIIT and VIIT 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.

When our interest is on the Smooth Adjustment Hypothesis (SAH), the conventional decomposition into HIIT and VIIT is appropriate.¹⁰ However, when our focus is on quality difference, the dichotomous decomposition of IIT into HIIT and VIIT by arbitrary chosen thresholds is problematic. This is because crucial information on how much prices differ is thrown away by the binomial

¹⁰ The SAH originally argues that if increases in trade are inter-industry in nature, the associated adjustment costs will be more severe than if the trade changes were intra-industry in nature. This is because a change in inter-industry trade generally requires more resource allocation than a change in intra-industry trade. Greenaway et al. (2002) and Brühlhart and Elliott (2002) apply the SAH argument to the distinction between HIIT and VIIT. In VIIT, product quality of exports and imports is different. Thus, resource requirement of high quality variety and low quality variety is different, while resource requirement of HIIT, where there is no difference in quality, does not vary across varieties. This is analogue to the argument of inter-industry versus intra-industry. Thus, VIIT entails higher adjustment costs than HIIT.

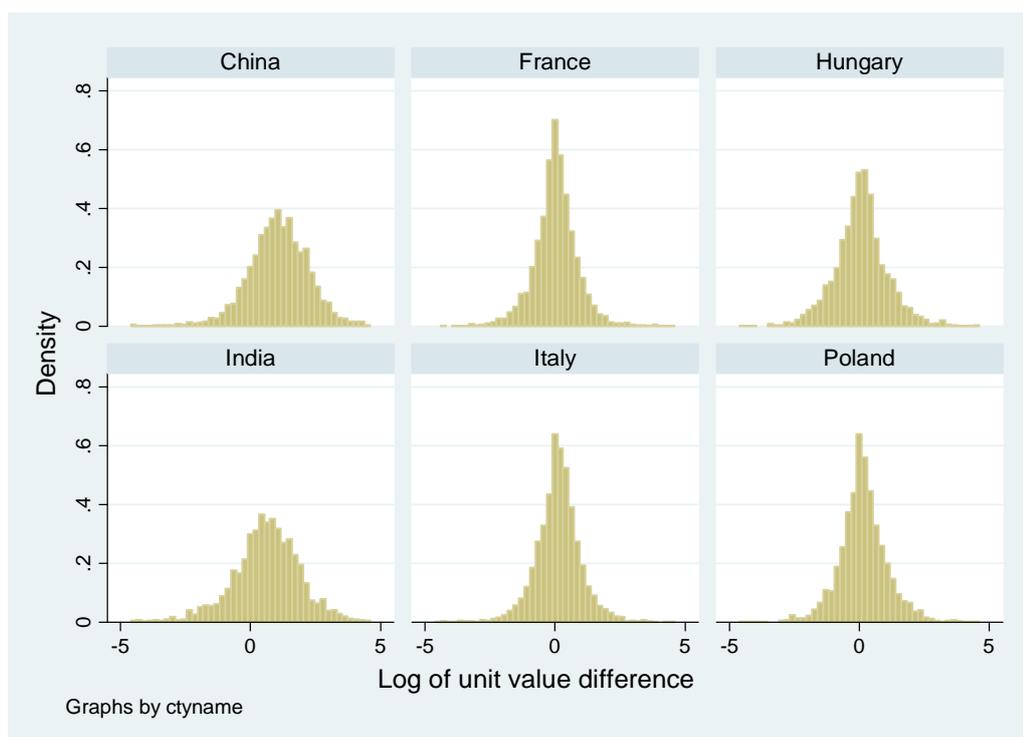
categorisation. For this end, we propose two methods. One is to compute the price difference of all IIT products and look at the distribution. The price difference of an IIT product is defined as the log of export price divided by import price, i.e.,

$$\text{PriceDifference} = \log(UV^X / UV^M)$$

UV^X is export unit value; UV^M is import unit value. This index is unit free and zero represents no price difference between imports and exports.

We take the natural logs of unit value ratios to address what Azhar and Elliott (2006) calls the “scaling or proportionality problem”, which is inherent to GHM and FF. Detailed argument on this issue is in the Appendix. We compute the price difference for all the IIT products for a pair of countries and take the distribution. For example, approximately 5000 data points of price differences are computed for Germany's IIT with France because there are about 5000 IIT products between these countries. 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 difference is centered around zero with a relatively high kurtosis. On the other hand, the distribution of unit price differences of Germany's IIT with China and India shows that the mean is clearly positive and kurtosis is low. The cases with Poland and Hungary are between these two cases. While Figure 20 only shows snapshots of the year 2007, by comparing the distributions over time, we can also see the evolution.

Figure 20: Distribution of IIT products price difference of Germany with some selected countries in year 2007



While visually appealing and allowing us to see more information on the distribution, the above measure of price difference has some drawbacks. First, it is not useful for comparing many countries over long time periods, because it is difficult to make exact comparisons when looking at many distributions. For such a comparison, we need a single number which represents the unit price difference of IIT for each trade pair for a given year. Second, in the above simple analysis of price difference, one data point is equally treated with another data point, even though the trade value and the GL-index may be substantially different between these two products. Figure 20 shows that the unit price differences of Germany's IIT with China are distributed toward a number above zero. However, if those products with unit price difference above zero represented only small trade values, the distribution would give us a false impression that Germany's IIT is characterised by Germany's high quality goods exports to China against China's low quality goods exports to Germany. The same can be said for the product level GL-index. Namely, if those products with unit price difference above zero had a low product level GL-index, it would give us the same false impression. In other words, in the above simple unit price difference measure, there is neither the dimension of relative trade values nor the magnitude of the "overlap" because we simply calculate price difference for each product whatever the trade value of each product is, and whatever the magnitude of "overlap" is (i.e., whatever the GL-index of each product is). In order to address these two drawbacks, the second measure we propose puts some weight on the unit value difference by trade values and on the magnitude of the "overlap".

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

$$UVDiffMeasureofIIT_{ij} = \sum_k \left[\log \left(\frac{ExUV_{ijk}}{ImUV_{ijk}} \right) \right] \left[\frac{\left(1 - \frac{|Ex_{ijk} - Im_{ijk}|}{Ex_{ijk} + Im_{ijk}} \right) (Ex_{ijk} + Im_{ijk})}{\sum_k \left(\left(1 - \frac{|Ex_{ijk} - Im_{ijk}|}{Ex_{ijk} + Im_{ijk}} \right) (Ex_{ijk} + Im_{ijk}) \right)} \right] \quad (3)$$

where $ExUV_{ijk}$ is the export unit value of IIT product k between countries i and j . Similarly

for $ImUV_{ijk}$. The first term in the curly bracket represents the unit value difference of product k .

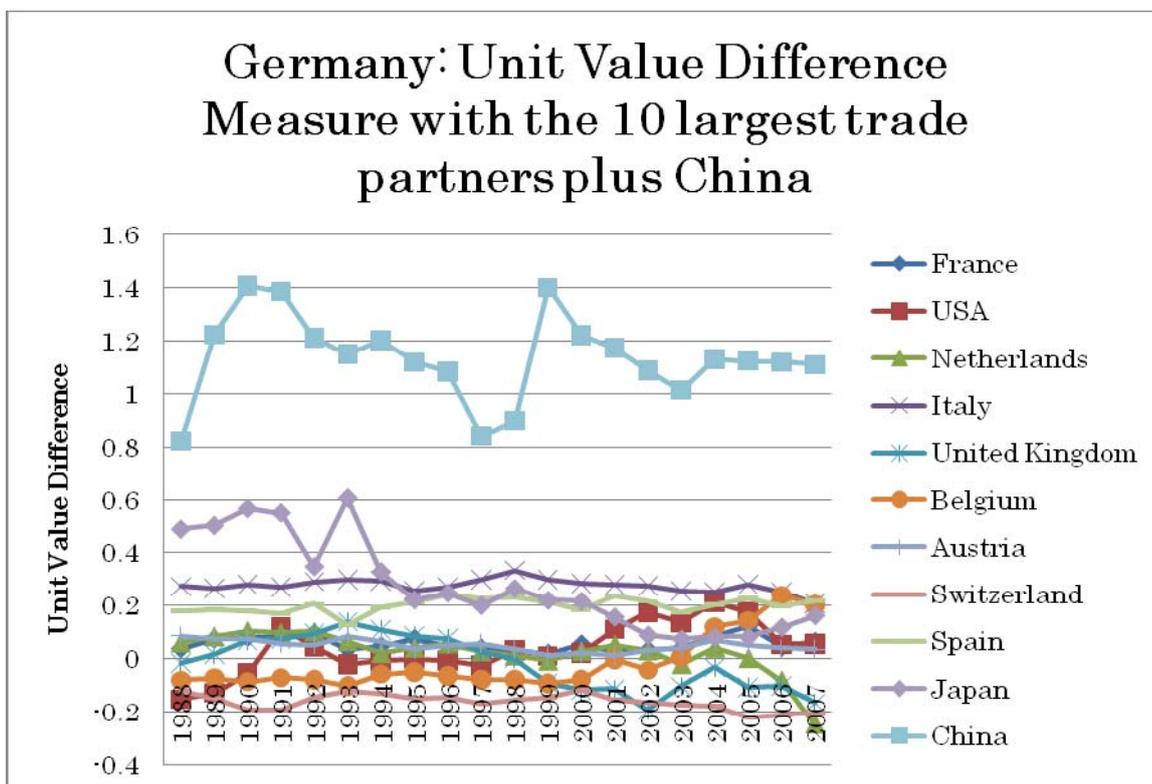
The term in the second curly bracket represents the share of IIT trade value of IIT product k (the numerator) among the total IIT trade value of all IIT products (the denominator). In other words, it represents how important product k 's IIT trade value is in the total IIT trade value. For example, if product k 's IIT trade value represents an extremely high share of the total IIT trade value, say 99 percent, the unit value difference of 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. This measure essentially captures

how vertical, upper-side or lower-side, the IIT between a pair of countries is.¹¹ Thus, we can also name this measure the “IIT vertical specialization index”.¹²

Figure 21 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 a 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 and the major EU countries, it even increases for the last ten years.

Figure 21: Germany – Unit Value Difference Measure with the 10 largest trade partners plus China



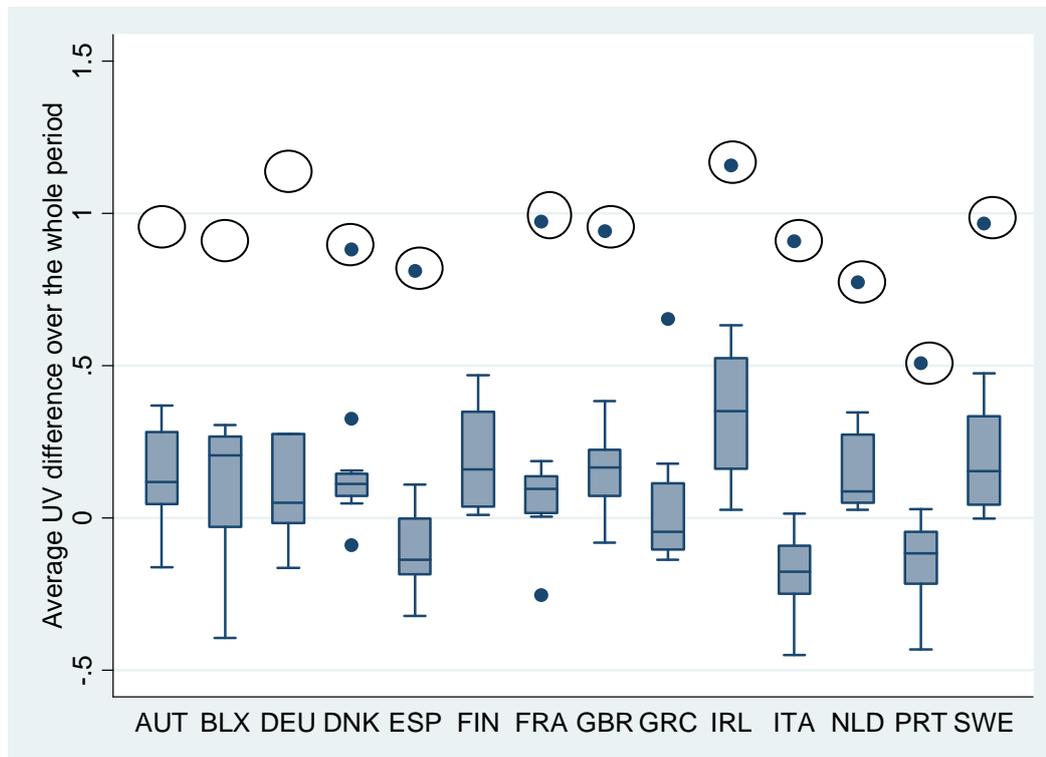
For the stark difference between China and the other 10 largest trade partners, the Box-and-whisker plot for all the EU-15 reporter countries (Figure 22) helps us to see if such is a common feature of

¹¹ We have found that Elliott (2006) briefly mentions a similar concept as “horizontalness” and “verticalness” of IIT. (Page 486)

¹² We thank Richard E. Baldwin for this naming.

EU-15 countries.¹³ Except Finland and Greece, unit value difference measures with China are clear outliers.

Figure 22: Box-and-whisker plot of Unit value difference measure with China and other major trade partners



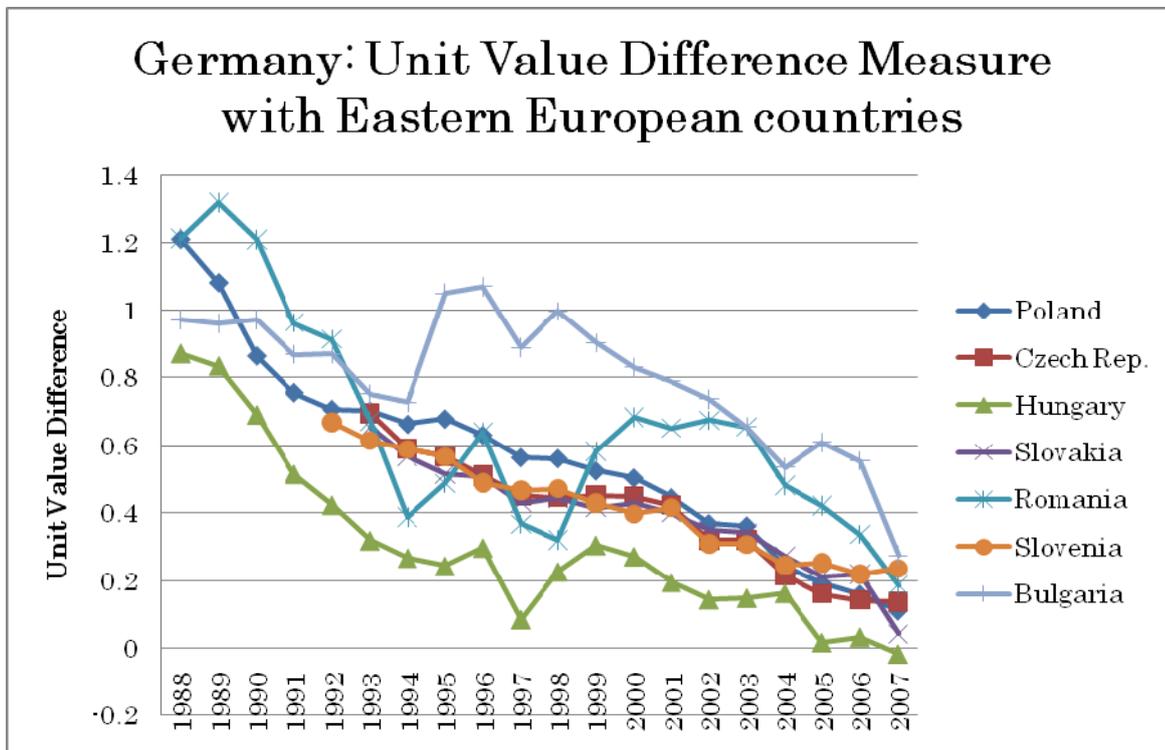
The circles indicate China.

Germany's Unit Value Difference Measure with Eastern European countries is in Figure 23. We can see a clear decreasing trend. 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 in 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

¹³ 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.

European countries achieved a level of around 0.2, which is close to the case of other major trade partners, such as Italy, Spain, Belgium or Japan

Figure 23: 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 regression¹⁴.

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

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

¹⁴ 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.)

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

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

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 register significant negative coefficients with Poland. The numbers are also high for the other Eastern European countries. Moreover, the second column indicates that cases of 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

*** represents statistical significance at 1percent.

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 FUTURE WORKS

Our paper studies two missing aspects of the existing IIT literature, i.e. the increased number of IIT products and the VIIT index highly depending on threshold values between HIIT and VIIT. We show some evidence in EU-15 trade that the number of IIT products rises and VIIT is active over the last decade. Based on this evidence we uncover the impact of the increased number of IIT products on the IIT index and also propose some alternative indices to measure VIIT without setting threshold values.

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 IIT, putting aside the determinants of IIT. It may be an interesting study to analyse the determinants of the change in EU 15's IIT with Eastern Europe, namely the driving force of Eastern Europe's rise up the quality ladder.

Future research is to more directly study the impacts of FDI and free trade agreements (FTA) on VIIT and HIIT and the evolution of IIT products using firm level data.

APPENDIX

Details on the computation of IIT index

In the computation of the 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 extreme numbers, we delete those observations whose export price is more than 100 times higher than import price, or less than 1/100th of import price.

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.

Argument on the “scaling or proportionality problem” in Section V

Azhar and Elliott (2006) explains the “scaling or proportionality problem” diagrammatically and rigorously. We interpret it in a simple way. The “scaling or proportionality problem” comes from the functional form of a UV ratio, UV^X/UV^M . The values of UV^X/UV^M are confined in the set of $(0, \infty)$ with 1 as the case of no difference in unit value. The cases of lower unit values of exports than imports are confined in the set of $(0, 1)$, while the cases of higher unit values of exports than imports are in the set of $(1, \infty)$. In other words, UV^X/UV^M for lower export unit values than import unit values are concentrated in a narrow set of $(0, 1)$, while UV^X/UV^M for higher export unit values than import unit values are in an unlimited set of $(1, \infty)$. This is “scaling or proportionality problem”. To

address this problem, Azhar and Elliott (2006) proposes what it calls Product Quality Vertical (PQV) index.

$$PQV = 1 + \frac{UV^X - UV^M}{UV^X + UV^M}$$

PQV index takes a value between 0 and 2. The geometrical center of 1 is the case of no unit value difference and the index value is symmetric above and below 1.

However, we think that confining the index into the limited set, i.e., (0,2) is problematic when we

like to compare the unit value difference of different goods or when we like to compute the index at industry level and/or country level. The virtues of PQV index and our measure and the problem of PQV index is best explained with numerical examples.

Numerical examples of PQV index and our measure

Case	UV ^x	UV ^m	PQV	UV ^x /UV ^m	ln(UV ^x /UV ^m)
1	90	90	1.00	1.00	0.00
2	90	10	1.80	9.00	2.20
3	10	90	0.20	0.11	-2.20
4	100	900	0.20	0.11	-2.20

Look at the above table. The fourth column shows the Product Quality Vertical Index of Azhar and Elliott (2006). In case 1, there is no difference in unit values of exports and imports, thus PQV takes the value of 1. Unit values of the cases 2 and 3 are opposite. PQVs have identical distance from 1, i.e., being free from what Azhar and Elliott (2006) calls the “scaling or proportionality problem”. In case 4, unit values of exports and imports are both inflated by 10 from case 3. PQV is unaffected by inflation, another virtue of the index.

We, instead, propose to take the natural logs of UV^X/UV^M . As the sixth column demonstrates, our measure also maintains the above nice features.

The next numerical example shows a problem arising from the bounded set of PQV index.

Case	UV ^x	UV ^m	PQV	UV ^x /UV ^m	ln(UV ^x /UV ^m)
1	90	90	1.00	1.00	0.00
2	90	60	1.20	1.50	0.41
3	90	30	1.50	3.00	1.10
4	90	10	1.80	9.00	2.20
5	90	1	1.98	90.00	4.50

Keeping unit value of exports at 90, we reduce unit value of imports. The fifth column shows the simple ratio of UV^x/UV^m . The sixth column is the natural log of the simple ratio. From case 1 to case 2, the unit value of imports goes down to 60, yielding PQV index of 1.20, which indicates a relatively higher quality of home country. From case 2 to case 3, the unit value of imports further declines to 30, giving a PQV index of 1.5 and so on. As the export unit value gets relatively higher, the PQV index approaches 2. However, as PQV index approaches the limit value of 2, it does not effectively reflect the real difference of unit values. Look at the case of 4 and 5; the export unit value is 9 times higher than the import unit value in case 4, which gives PQV index of 1.8. In the 5, the export unit value is 90 times higher than the import value, yielding a PQV index of 1.98. Although the ratio UV^x/UV^m gets 10 times higher from 9 to 90, the PQV index changes only slightly from 1.8 to 1.98. Thus, while the PQV index succeeds to get rid of the “scaling or proportionality problem”, it invites another kind of scaling problem (the “second” scaling problem). Keeping the information on the real unit value difference is essential when we like to compare how two products’ “verticality” is different, or when we like to compute how the unit values of IIT between a pair of countries as a whole is different because we should take into account the information of the “real” unit value difference when we aggregate product level unit value differences to compute an overall unit value difference measure.

Our measure using natural logs is not completely free from the “second” scaling problem because taking natural logs is scaling in nature and the scaling by natural logs dampens large numbers more than small numbers. However, the scaling problem of our measure is much smaller than that of the PQV index, which essentially comes from the unlimited set, $(-\infty, +\infty)$, unlike the PQV index, which confine the index into the limited set $(0, 2)$.

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 import value and takes the value

0.941. By multiplying the sum of export and import value, which is 17,000 in the current case, by IIT index of 0.941 it gives the IIT trade value of 16,000, which, in turn, is simply the overlapped value of imports and exports, i.e., 8,000 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 overall unit value difference measure, which is -0.079 in the current case.

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