The Measurement of Intra-Industry Trade between Unequal Partners

By

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I. Introduction

Measures of intra-industry trade (IIT) have been proposed since the mid-1960s when economists first gained interest in the subject. Two major problems with these measures have been identified. The first is the inappropriate grouping of industrial activities. Since there exists no standardized international level of trade or industry classification that ideally corresponds to an industry, it is difficult to assign the correct level of trade to the corresponding industry. Although this problem has been noted elsewhere scholars have not thoroughly analyzed the issue. The second problem, which has received much attention, is the treatment of trade imbalances in the measures of intra-industry trade. Several suggestions have been made on how to approach the problem, but none seems to have gained a wide acceptance among trade economists. In a recent study, Rajan (1996) shows the importance of distinguishing between the *degree* and the *level* of intra-industry trade, and demonstrates that the standard formula for measuring the degree of intra-industry trade, the Grubel-Lloyd index, fails to correctly reflect the level of intra-industry trade in the presence of trade imbalances.

This note argues that the failure of the Grubel-Lloyd index to correctly reflect the actual level of intra-industry trade does not only stem from the presence of trade imbalances, but also from the comparison of intra-industry trade between countries of unequal economic size. Empirical evidence reveals that countries with low *levels* of intra-industry trade still may show high *degrees* of intra-industry trade. The industrialized countries' intra-industry trade with the developing countries have increased over the years (see e.g. Culem and Lundberg 1986, Stone and Lee 1995, and Tharakan 1984, 1986). Interest has therefore also been focused on the intra-industry trade of

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many economically small countries of the world. The level of the developing countries' bilateral intra-industry trade with the industrialized countries appears to be inaccurately reflected in the degree of intra-industry trade in many cases. The measurement of the developing countries' intra-industry trade therefore requires further investigation.

II. Levels and Degrees of Intra-Industry Trade in the Presence of Large and Small Countries

Even though a variety of measures of intra-industry trade have been proposed (see Greenaway and Milner 1986: Chapter 5), the most commonly used formula dates back to Grubel and Lloyd (1975). They define country j's intra-industry trade in product category i as:

$$GL_i = 1 - |X_i - M_i|/(X_i + M_i), \tag{1}$$

where X_i = country j's exports of goods in product category i and M_i = country j's imports of goods in product category i. Intra-industry trade at the aggregate level is defined as the weighted average of the industry indices in (1), the weights being based on the share of the industry in total trade:

$$GL = 1 - \sum |X_i - M_i| / \sum (X_i + M_i). \tag{2}$$

It is well known that the GL index will be biased downwards by the size of the overall trade imbalance, $\sum |X_i - M_i|$, (see e.g. Aquino 1978, Grubel and Lloyd 1975, Kol and Mennes 1989, and Vona 1991).

The GL index is a measure of the degree of intra-industry trade rather than of the absolute amount of intra-industry trade. Greenaway and Milner note, however, that "...it tends to be used indiscriminately as a measure of both aspects ..." (1987: 44).

Rajan (1996) argues that it is necessary to make a distinction between the level and the share of intra-industry trade since the GL index does not correctly reflect the level of intra-industry trade. Assuming a one-commodity three-country world (countries A, B and C), focusing on country A's bilateral trade with her two partner countries, Rajan's example is partially replicated in the first part of Table 1. Two columns are added to the original table, one denoting the level of intra-industry trade and the other an index of aggregate trade imbalances, $\sum |X_i - M_i| / \sum (X_i + M_i)$. In Case 3, the GL index fails to reflect the higher level of intra-industry trade between A and B compared to A's intra-industry trade with C. Rajan therefore correctly argues that

Table 1 – *Country A's Bilateral Trade with Countries B, C, D and E*

Country	X	M	$(X+M)$	Trade imbalance $(X-M)$	GL	Level of IIT	Trade imbalance (index)
				Case 3			
B	1,500	3,000	4,500	−1,500	67	3,000	0,33
C	1,000	750	1,750	250	86	1,500	0,14
				Case 4			
D	2,000	1,500	3,500	500	86	3,000	0,14
E	10,000	7,500	17,500	2,500	86	15,000	0,14

Source: Case 3 is partially replicated from Rajan (1996: 380).

the GL index gives a misleading idea of both the extent and the level of intra-industry trade.

Rajan asserts that the problem arises as a result of the higher trade imbalance between A and B (1,500) as opposed to the trade imbalance between A and C (250). But suppose that a comparison of intra-industry trade is to be made with a third country, country D (Case 4), whose Gross National Product (GNP) is twice that of C's. Therefore assume that country D's export, import and trade imbalance are two times that of C's. As can be seen, the absolute volume of intra-industry trade is now equally great between A and B and between A and D. However, the degree of intra-industry trade according to the GL index remains unchanged. That is, although the level of intra-industry trade now is equal in the two cases, the GL index indicates a more intensive intra-industry trade between countries A and D.

Now consider the effect of adding an additional trade partner, country E, to the example. Country E's GNP is ten times that of country C, so assume that E's export, import and trade imbalance are ten times greater than C's. The volume of country A's intra-industry trade with country E equals 15,000. Comparing A's intra-industry trade with B to A's intra-industry trade with E shows that the GL indices now correctly reflect the higher level of intra-industry trade between A and E. Case 4 demonstrates that the presence of trade imbalances does not necessarily imply that the GL index fails to accurately reflect the level of intra-industry trade. However, Case 4 shows that for a given size of the trade imbalances, the GL index may fail to correctly reflect the actual level of intra-industry trade if the difference in volume between two country-pairs' bilateral intra-industry trade flows is large.

III. The Importance of Economic Size

The central role of monopolistic competition, domestic market size, and economies of scale in the theory of intra-industry trade (see e.g. Helpman and Krugman 1985) suggests that country size is an important determinant of intra-industry trade. Country size may be measured in several different ways (see Perkins and Syrquin 1989). The size of a nation's domestic market "... is related more to the size of its GNP than it is to the number of people who live there ..." (ibid: 1712). GNP may thus be considered a suitable proxy for country size in the context of intra-industry trade. Country size, as measured by GNP, plays a central role also in the so-called gravity model (see e.g. Baldwin 1994, Bergstrand 1985, 1989, and Deardorff 1995). In the model, trade is proportional to the exporting countries' and the importing countries' GNP.

As seen in the section above, country size is related to the measurement of intra-industry trade since countries with higher GNPs tend to proportionally display both larger trade volumes and larger trade deficits. Developing countries, on the other hand, often have small GNPs and have intra-industry trade in very few product groups (industries). Consequently, a developing country's level of intra-industry trade with a developed country may be quite low. If total trade between them also is low, the GL index may however still indicate that intra-industry trade between the two countries is substantial and important.

Consider the example in Table 2 of Germany's intra-industry trade with some economically small and large developing countries, respectively. Germany's economic size, as measured by GNP, amounted to 1,776 billion U.S. dollars in 1990 (see World Bank 1995). The small countries' GNP reach some 0.2 per cent of this figure at the top, while the economic size of Brazil, Hong Kong, and Korea Republic is substantially larger amounting to 23, 4 and 13 per cent of Germany's GNP. The economic size of the developing countries partly seems to be associated with the number of products they trade. The economically large countries in the table trade in many more products than the small countries do. Economic size also seems to be reflected in the number of products in which they have positive intra-industry trade. Two of the three small developing countries in the example have intra-industry trade in less than ten product groups, while the large developing countries display intra-industry trade with Germany in more than 200 product groups.

Table 2 – *An Example of Germany's Intra-Industry Trade in 1990 (million US dollars)* [a]

Partner country	% of Germany's GNP	$\Sigma(X+M)$	$\Sigma[X-M]$	No. of prod. traded	No. of prod. IIT traded	Trade imbal-ance	GL	Level of IIT
Small countries								
Bahamas	0.17	367	189	100	6	0.52	0.48	178
Malta	0.13	482	367	307	101	0.76	0.24	115
St Kitts & Nevis	0.008	27	16	149	7	0.59	0.41	11
Large countries								
Brazil	22.83	4,654	3,824	383	227	0.82	0.18	830
Hong Kong	3.84	7,167	5,930	372	254	0.83	0.17	1,237
Korea RP	13.16	6,032	4,916	374	253	0.81	0.19	1,117

[a] Figures may not add up due to rounding off.

Source: Own calculations based on figures from Statistic Canada's World Trade Data Base.

Germany's intra-industry trade with the three small countries, as measured with the GL index, are greater and more extensive than corresponding trade with the large countries. For instance, in the case of St. Kitts and Nevis, intra-industry trade with Germany measures 0.41 with the GL index, while total intra-industry trade between them amounts to 11 million dollars in seven product groups. Germany's GL index with Hong Kong amounts to 0.17 for a value of intra-industry trade of 1,2 billion dollars in 254 product groups. If, instead, the actual level of intra-industry trade is looked upon, it can be seen that Germany's total intra-industry trade with the three small countries only reach some 25 per cent of Germany's intra-industry trade with Hong Kong.

The failure of the GL index to correctly reflect the level of intra-industry trade may partly be explained by the relative size of the trade imbalances. The measure of relative trade imbalances equals one minus the GL index (cf. expression (2)). Hence, the country with the largest relative trade imbalance will always display the lowest degree of intra-industry trade according to the GL index, irrespective of the level of intra-industry trade. Likewise, the country with the lowest relative trade imbalance will always display the largest share of intra-industry trade.

IV. Effects of Proposed Adjustment Procedures for Trade Imbalances

As of today, no consensus exists among scholars on how to adjust for trade imbalances when measuring intra-industry trade. Grubel and Lloyd (1975) proposed that their index in (2) be adjusted for the impact of the overall trade imbalance by expressing intra-industry trade as a proportion of total trade minus the trade imbalance:

$$GL_{adj} = GL/(1-k), \tag{3}$$

where GL equals (2) and $k = [\sum X_i - \sum M_i|/\sum(X_i + M_i)$. Aquino (1978) was critical to this approach and suggested that (2) be adjusted with estimates of what the values of exports (X) and imports (M) of each commodity would have been if total exports had been equal to total imports in the following way:

$$Q = 1 - \sum|X_{iq} - M_{iq}|/\sum(X_i + M_i), \tag{4}$$

where $X_{iq} = X_i(1/2)\sum(X_i + M_i)/\sum X_i$ and M_{iq} is analogously defined.

To mitigate the shortcoming of the GL index in the presence of trade imbalances, Rajan (1996) proposes a new measure of intra-industry trade at industry and country level:

$$R_i = \{(\text{Min}(X_i, M_i)/2M_i) + (\text{Min}(X_i, M_i)/2X_i)\} \times 100 \tag{5}$$

$$R = \sum\{((X_i + M_i)/(\sum X_i + \sum M_i)) + R_i\}. \tag{5a}$$

In contrast to the other proposed indices of intra-industry trade ranging between 0 and 1, the index is bounded between 50 and 100 according to Rajan. One drawback of the index in (5) is "... when there is no IIT, the index has an infinite value as one of the divisors equals zero ..." (Rajan 1996: 383). However, he asserts that the problem is trivial and may simply be remedied by manually setting the index equal to zero in such cases.

Greenaway and Milner (1987: 44) succinctly summarize the grounds for Greenaway and Milner's (1981) questioning of the whole rationale for adjusting for trade imbalances "... we have no a priori knowledge of the particular set of transactions which will be balanced in equilibrium nor do we know the nature and the effects of the (balance of payments) adjustments forces initiated by imbalance."

Aquino's (1978) attempt to adjust for trade imbalances is more specifically criticized by Greenaway and Milner (1981) for the underlying assumption that trade imbalances are spread equiproportional in all industries. Several authors have been critical to the proposed attempts to correct the GL index for trade imbalances. Helpman

Table 3 – *A Comparison of Various Measures of Germany's Intra-Industry Trade in 1990 (absolute values of intra-industry trade in million US dollars)*

Partner country	Level of intra-industry trade	GL	GI_{adj}	Aquino	Rajan[a]
Small countries					
Bahamas	178	0.48	0.91	0.91	63
Malta	115	0.24	0.24	0.24	52
Large countries					
Hong Kong	1,237	0.17	0.33	0.22	55
Korea RP	1,117	0.19	0.19	0.18	55

[a] The Rajan index does not range between 0 and 1 as the other indices do.

Source: Own calculations based on figures from Statistic Canada's World Trade Data Base.

(1987) argued that the bias generated by the trade imbalances depends on its source and that no simple adjustment is possible, while Kol and Mennes (1989) and Vona (1991) claim that correcting for trade imbalances is undesirable on both theoretical and empirical grounds.

Previously proposed adjustment procedures have never had the explicit intention to accomplish a correct reflection of the level of intra-industry trade of the GL index.[1] Nevertheless, it is still interesting to evaluate the effectiveness of the adjusted indices to the problem at hand. In Table 3 alongside the unadjusted GL indices, we also find adjusted GL indices, Aquino indices, and Rajan's proposed indices of Germany's intra-industry trade with selected countries in 1990. None of the proposed adjustments is capable of eliminating the failure of the unadjusted GL index to accurately reflect the level of intra-industry trade. The adjusted GL index corrects Germany's GL index with Hong Kong upwards, but the index still indicates a more intensive intra-industry trade between Germany and Bahamas. Rajan's index correctly indicates a higher level of intra-industry trade between Germany and the large countries in the table compared to intra-industry trade between Germany and Malta. Still, Rajan's indices suggest that intra-industry trade between Germany and Bahamas is more extensive compared to intra-industry trade between Germany and Hong Kong or between Germany and Korea Republic.

[1] One exception is Milner (1988) who considered the problem of weighting when comparing the importance of intra-industry trade between industries.

Table 4 – *Germany's Intra-Industry Trade with Kiribati in 1990 (thousand US $)*

Partner country	SITC	X	M	$(X+M)$	$[X-M]$	Level of IIT	Rajan
Kiribati	9310	237	63	300	174	126	$R_i=63.3$
	Total	$\Sigma=790$	$\Sigma=130$	$\Sigma=920$	$\Sigma=794$	$\Sigma=126$	$R=20.6$

Source: Own calculations based on figures from Statistic Canada's World Trade Data Base.

If a large share of the trade between two countries is of inter-industry nature, Rajan's index (5a) can be shown to fall outside the stipulated bounds between 50 and 100. When X_i or M_i equals zero, the index in (5) approaches infinity and Rajan suggests that these figures be manually replaced with zeroes. This manoeuvre is not appropriate since the index in (5) is part of the aggregated index in (5a). Consider Germany's intra-industry trade with Kiribati in 1990, a year in which they had intra-industry trade with each other in only one product (see Table 4). The R_i index should therefore be set to zero in (5) in all but one case and therefore also in (5a) which contains the R_i term. Inter-industry trade, however, took place in as many as 20 products. The sum of exports and imports therefore took on relatively high values compared to intra-industry trade. As a result, Rajan's (5a) index yields a value of 20.6 which is well below the stipulated lower bound of the index.

V. Alternative Measure of Intra-Industry Trade

The sections above show that the various measures of intra-industry trade poorly reflect the actual level of intra-industry trade. One may therefore have problems establishing empirical relationships between the most common explanatory variables derived from theoretical work, similarities in economic size and factor endowments (see e.g. Helpman and Krugman 1985), and the share of intra-industry trade. Hence, there is a need to develop and to improve the existing measures of intra-industry trade. The most obvious solution would simply be to use levels of intra-industry trade. It has one drawback, though. Using levels of intra-industry trade makes it difficult to compare the extent of intra-industry trade specialization between countries, since larger countries are inclined to display higher levels of trade in general, and therefore also of intra-industry trade. Instead, it is suggested that the level of intra-industry trade be divided by the number of all products

Table 5 – *A Comparison of the Ranking of the Level of IIT, of the Level of IIT per Product and of the GL Index of Germany's Intra-Industry Trade with Selected Countries in 1990 (levels and IIT per product in thousand US $)*

Country	Level of IIT	Rank	IIT per product (IITp)	Rank	GL	Rank
Hong Kong (L)	1,237,106	**1**	3,326	**1**	0.17	7
Korea RP (L)	1,116,656	**2**	2,986	**2**	0.19	5
Brazil (L)	829,758	**3**	2,166	**3**	0.18	6
Turkey	819,550	**4**	1,906	**4**	0.11	10
Romania	364,126	**5**	1,023	**5**	0.21	4
Bahamas (S)	177,508	**6**	1,775	**6**	0.48	1
Malta (S)	114,664	**7**	373	**7**	0.24	3
Qatar	18,460	**8**	78	**8**	0.15	**8**
St. Kitts & Nevis (S)	10,534	**9**	71	**9**	0.39	2
Cameroon	1,912	10	8	11	0.01	17
Zambia	1,888	11	9	10	0.02	13
Zimbabwe	1,826	**12**	7	**12**	0.01	18
Zaire	1,544	13	6	15	0.00	20
Madagascar	1,312	14	7	13	0.02	**14**
Ecuador	1,176	15	5	16	0.01	19
Jamaica	778	16	5	17	0.02	15
Barbados	484	17	3	19	0.03	11
Burkina Faso	444	**18**	4	**18**	0.03	12
Maldives	184	19	3	20	0.02	16
Kiribati	126	20	6	14	0.14	9

Note: Figures in bold denote cases where the ranking of the level of IIT is matched by the ranking of IIT per product and the GL index, respectively. (L) and (S) denote the large and small countries of Table 2.

Source: Own calculations based on figures from Statistic Canada's World Trade Data Base.

traded between two countries to yield a measure of the average level of intra-industry trade per product:

$$IITp_{ij} = \frac{Level\ IIT_{ij}}{No.\ of\ products\ traded}. \tag{6}$$

This measure reflects the actual level of intra-industry trade between two countries, facilitates a comparison of the extent of intra-industry trade between large and small countries, and is transparent and easily computed.

In Table 5, Germany's intra-industry trade with 20 developing countries in 1990 is ranked according to the level of intra-industry

trade. The ranking of the top nine countries remains unchanged when the countries are ranked according to the level of intra-industry trade per product, and among the remaining 11 countries in the table two more are matched. In contrast, ranking according to the size of the GL index is not so succesful. Only two of the twenty intra-industry trade partners match the ranking of the level of intra-industry trade. Referring back to the large (L) and small (S) countries of Table 2, it can be seen (in Table 5) that measuring intra-industry trade per product correctly reflects the level of intra-industry trade. Moreover, the correlation coefficient between the level of intra-industry trade and intra-industry trade per product in Table 5 is high (0.96), revealing that intra-industry trade per product is a suitable proxy for the level of intra-industry trade. On the other hand, the correlation coefficient between the level of intra-industry trade and the GL index is only 0.27 illustrating that the GL index is a poor indicator of the level of intra-industry trade.

Intra-industry trade may also be measured at the industry level with this method. Consider Turkey's intra-industry trade with Germany in subgroups at the 4-digit level of SITC 892 and SITC 899 in 1990 (see Table 6). The second column shows the aggregation level, the third column denotes the level of intra-industry trade, and the fourth column gives the level of intra-industry trade per product for the various levels of aggregation. First, summing up the level of intra-in-

Table 6 – *An Illustration of How the Measure Intra-Industry Trade per Product May Be Applied at Industry Level (levels and IIT per product in thousand US $)*

Partner country	SITC		Level of IIT	IIT per product (IITp)
Turkey	8,925		0	
Turkey	8,928		2,120	
	892	Sum	2,120	SITC 892 1,060 (2 products)
Turkey	8,997		594	
Turkey	8,998		6,490	
Turkey	8,999		498	
Turkey	899	Sum	7,582	SITC 899 2,527 (3 products)
Turkey	89	Sum	9,702	SITC 89 4,851 (2 products)

Source: Own calculations based on figures from Statistic Canada's World Trade Data Base.

dustry trade at the 4-digit level yields the level of intra-industry trade at the 3-digit level. Then, dividing the level of intra-industry trade at the 3-digit level with the number of categories added up, i.e. with the total number of products traded, at the category's 4-digit level gives the measure of intra-industry trade per product at the 3-digit level. Similarly, if a measure of intra-industry trade at the 2-digit level is wanted, sum up the level of intra-industry trade at the 3-digit level to yield a measure of the level of intra-industry trade at the 2-digit level. Thereafter, divide the level of intra-industry trade at the 2-digit level with the number of categories added up at the 3-digit level.

VI. Summary

This note argues that the inadequacy of the GL index to correctly reflect the level of intra-industry trade in presence of trade imbalances may partly be due to measuring intra-industry trade between countries with large differences in economic size. Several adjustment procedures have been suggested in the literature but it is demonstrated that none of the alternative measures seem capable of eliminating the problem. A new measure of intra-industry trade is proposed in which the bilateral level of intra-industry trade is divided by the total number of products traded between two countries to yield an average level of intra-industry trade per product. This measure may also be applied at industry level, and in contrast to the GL index, it is highly correlated with the actual level of intra-industry trade.

In studies of intra-industry trade, one should cautiously interpret the GL index since it may give a false picture of the extent and the volume of intra-industry trade. If the standard GL index is used, it is suggested that also alternative measures of intra-industry trade are employed to complement the GL index in order to correctly observe the true extent of intra-industry trade.

References

Aquino, A. (1978). Intra-Industry Trade and Inter-Industry Specialization as Concurrent Sources of International Trade in Manufactures. *Weltwirtschaftliches Archiv* 114(2): 275–295.

Baldwin, R. E. (1994). *Towards an Integrated Europe*. London: CEPR, Centre for Economic Policy Research.

Bergstrand, J. H. (1985). The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence. *The Review of Economics and Statistics* 67(3): 474–481.

Bergstrand, J. H. (1989). The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade. *The Review of Economics and Statistics* 71(1): 143–153.

Culem, C., and L. Lundberg (1986). The Product Pattern of Intra-Industry Trade: Stability among Countries and over Time. *Weltwirtschaftliches Archiv* 122(1): 113–130.

Deardorff, A. V. (1995). Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World? NBER Working Paper 5377. Cambridge, Mass.

Greenaway, D., and C. Milner (1981). Trade Imbalance Effects in the Measurement of Intra-Industry Trade. *Weltwirtschaftliches Archiv* 117(4): 756–762.

— (1986). *The Economics of Intra-Industry Trade.* Oxford: Basil Blackwell.

— (1987). Intra-Industry Trade: Current Perspectives and Unresolved Issues. *Weltwirtschaftliches Archiv* 123(1): 39–57.

Grubel, H., and P. J. Lloyd (1975). *Intra-Industry Trade.* London: The MacMillan Press Ltd.

Helpman, E. (1987). Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries. *Journal of the Japanese and International Economies* 1(1): 62–81.

Helpman, E., and P. R. Krugman (1985). *Market Structure and Foreign Trade.* Cambridge, Mass.: The MIT Press.

Kol, J., and L. B. M. Mennes (1989). Corrections for Trade Imbalance: A Survey. *Weltwirtschaftliches Archiv* 125(4): 703–717.

Milner, C. (1988). Weighting Considerations in the Measurement and Modelling of Intra-Industry Trade. *Applied Economics* 20(3): 295–301.

Perkins, D. H., and M. Syrquin (1989). Large Countries: The Influence of Size. In H. Chenery and T. N. Srinivasan (eds.), *Handbook of Development Economics, Vol. II.* Amsterdam: North-Holland.

Rajan, R. S. (1996). Measures of Intra-Industry Trade Reconsidered with Reference to Singapore's Bilateral Trade with Japan and the United States. *Weltwirtschaftliches Archiv* 132(2): 378–389.

Stone, J. A., and H.-H. Lee (1995). Determinants of Intra-Industry Trade: A Longitudinal, Cross-Country Analysis. *Weltwirtschaftliches Archiv* 131(1): 67–85.

Tharakan, P. K. M. (1984). Intra-Industry Trade between the Industrial Countries and the Developing World. *European Economic Review* 26(1–2): 213–227.

— (1986). The Intra-Industry Trade of Benelux with the Developing World. *Weltwirtschaftliches Archiv* 122(1): 131–149.

Vona, S. (1991). On the Measurement of Intra-Industry Trade: Some Further Thoughts. *Weltwirtschaftliches Archiv* 127(4): 678–700.

World Bank (1995). *World Tables.* Baltimore: The Johns Hopkins University Press.