BANCA D'ITALIA

Temi di discussione

del Servizio Studi

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The purpose of the «Temi di discussione» series is to promote the circulation of working papers prepared within the Bank of Italy or presented in Bank seminars by outside economists with the aim of stimulating comments and suggestions.

The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.

Stefano Vona died on 27 November of this year, after a long illness that sapped his physical but not his intellectual strength. The works that he published during the year are testimony of this, as is this article, which he submitted to the editorial committee just a few days before his death. He did not have time to make a final revision, but, apart from a few formal changes, we have decided to publish it as he gave it to us.

The editorial committee, of which Stefano Vona was a member from 1987 to the beginning of this year, wishes to take this opportunity to commemorate an economist of considerable insight and a colleague who possessed rare professional and human qualities.

1. Introduction

Both the empirical and the theoretical literature on intra-industry trade (IIT) has developed rapidly during the last fifteen years. IIT occurs when countries simultaneously export and import goods produced by the same industries. This phenomenon is not envisaged by the standard comparative advantage theory of international trade and requires explanations based upon factors such as scale economies, product differentiation, imperfect markets and consumers' taste for variety, which are not considered in the world of perfect competition of the standard theory. The existence of IIT thus stimulated the development of new trade theories in competition with that based on comparative advantage. Assessing their importance relative to the standard theory in explaining patterns of trade in the real world is essentially an empirical matter. There are, however, two unresolved problems which seriously undermine the empirical results on this subject. The first is the very existence of IIT and concerns the definition of "industry" and the level of data disaggregation at which the phenomenon is best observed. The second problem stems mainly from the objective difficulty of finding a suitable quantitative measure of IIT. This is at least partly linked with the first problem, but it can be treated separately for the sake of simplicity.

This paper addresses the second of these two problems and is organized as follows: section two is devoted to the examination of Grubel and Lloyd's indices, those most used in empirical studies of IIT up to now. Section three reviews the measure proposed by Aquino and presents some criticisms. Section four is devoted to a discussion of the view that measures of IIT should be corrected for the overall trade imbalance. Section five shows why Grubel and Lloyd's uncorrected index seems to be the best of those available at present. In section six a new measure is presented together with some preliminary calculations. Finally, section seven sums up the main conclusions reached in the article.

2. Grubel and Lloyd's indices

While measures of IIT appeared in the literature long before the seventies (Verdoorn, 1960; Kojima, 1964; Balassa, 1966),[1] it was only in 1971 and 1975, with two contributions from Grubel and Lloyd, that the measurement problems were explicitly raised and discussed. The solution proposed by Grubel and Lloyd (henceforth G-L) was subsequently disputed by Aquino (1978), who was later criticized by Greenaway and Milner (1981; 1983). One cannot avoid entering this debate in conducting an empirical study of IIT.[2]

Grubel and Lloyd devoted a chapter of their 1975 book to an examination of the indices used in previous works and then proposed one of their own which was a modification of the one Balassa had used to assess the effects of the formation of the Common Market on the international specialization of the EEC countries involved, with special reference to the question whether the EEC led to inter- or to intra-industry specialization. Balassa's indices are presented in the following formulas:

$$C_i = \frac{|X_i - M_i|}{X_i + M_i} \quad (1)$$

$$C = \frac{1}{n} \sum_{i=1}^{n} C_i \quad (2)$$

where X_i and M_i indicate the exports and imports of a certain country in industry i. Summing across industries and taking the arithmetic mean leads to a measure (C) of the degree of a country's inter-industry specialization (the complement to unity of C measures the degree of intra-industry specialization).

1. It should be noted that some of the authors mentioned did not deal directly with the problem of IIT; IIT was a by-product of their research work but not its main focus.

2. More recent contributions to this discussion have been made by Greenaway (1984), Pomfret (1985) and Greenaway and Milner (1985, 1987).

If exports and imports tend to match each other in each industry, the index approaches zero. According to Balassa, this signifies a low degree of inter-industry specialization (with a correspondingly high degree of intra-industry specialization). On the other hand, if exports and imports differ widely, the index approaches unity, indicating high inter-industry specialization (and low intra-industry specialization).

Grubel and Lloyd criticized Balassa's index both because it is a simple arithmetic mean of each industry's index (and thus fails to reflect the different weight of each industry), and because it does not take account of the need to correct for aggregate trade imbalances. While there is general agreement on the first point raised by G-L and on the solution they proposed, their second criticism and the proposed solution gave rise to the debate referred to above.

Grubel and Lloyd introduced a simple transformation of the Balassa index in order to measure the extent of IIT at an elementary industry level:

$$B_i = (1-C_i) \cdot 100 \qquad (3)$$

They then aggregated the B_i across industries taking account of their different weights, proxied by the ratios of each industry's exports plus imports to the total value of exports plus imports of the whole sample of industries considered. The weighted average was then defined by the following formula:

$$\bar{B}_i = \sum_{i=1}^{n} B_i \, (X_i+M_i) / \sum_{i=1}^{n} (X_i+M_i) = \frac{\sum_{i=1}^{n} (X_i+M_i) - \sum_{i=1}^{n} |X_i-M_i|}{\sum_{i=1}^{n} (X_i+M_i)} \cdot 100 \qquad (4)$$

Grubel and Lloyd observed that "the mean is a biased downward measure of intra-industry trade if the country's total commodity trade is imbalanced or if the mean is an average of some subset of all industries for which exports are not equal to imports. With an imbalance between exports and imports, the mean must be less than 100 no matter what the pattern of exports and imports, because exports cannot match imports in every industry. This is an undesirable feature of a measure of average intra-industry trade which is due to the fact that it captures both the trade imbalance and the strength of the intra-industry trade" (1975, p. 22).

Without any further analysis of this point, which later appeared rather important, G-L proposed to deal with the problem by subtracting the global trade imbalance from the total amount of trade in the denominator of $\bar{B}_i$, that is:

$$(5) \qquad \bar{C}_i = \frac{\sum_{i=1}^{n} (X_i+M_i) - \sum_{i=1}^{n} |X_i-M_i|}{\sum_{i=1}^{n} (X_i+M_i) - \left| \sum_{i=1}^{n} X_i - \sum_{i=1}^{n} M_i \right|} \cdot 100$$

In other words IIT is now measured with respect to total balanced trade and not to total trade; thus G-L claim to have corrected the downward bias of the $\bar{B}_i$ measure. The subsequent literature on this subject generally accepts the G-L arguments concerning the need to adjust for trade imbalances and the correction procedures, with the notable exception of Aquino (1978), who disputes the procedure proposed by G-L.

Before turning to the discussion of Aquino's correction, it is worth mentioning here that the "need for correction argument" evidently views international trade as falling into three different categories: (a) inter-industry trade; (b) intra-industry trade; (c) trade imbalances. The third category does not belong to either of the two types of international specialization considered (inter or intra-industry), and is in fact excluded from the analysis as a disturbing factor (formula (5)). This is one of the fallacies of the "need for correction argument", as will be shown in section 4.

3. Aquino's measure

Aquino (1978) first criticizes the G-L correction for total imbalance and then extends his criticism to the whole index. He argues that if the $\bar{B}_i$ are a downward biased measure of IIT, then the elementary measure (B_i) is also downward biased. "This because one cannot possibly maintain that the overall imbalance has not an imbalancing effect on the single commodities' trade flows and then recognise that the imbalancing effects appear at the highest level of industry aggregation" (p. 280). Furthermore, he notes that the correction proposed by G-L for the aggregate measure cannot be applied to an elementary level. According to Aquino, it is precisely because G-L failed to correct their proposed measure at the most disaggregate level that the aggregate measure performs unsatisfactorily.

Aquino then proposes another index for measuring IIT. "The most straightforward way of correcting for the overall imbalance at the elementary level ... (under the assumption that the imbalancing effect is equiproportional in all industries) requires an estimate of what the values of exports and imports of each commodity would have been if total exports had been equal to total imports. Denoting with a superscript "e", these theoretical values of exports and imports, these can be obtained as follows" (p. 280):

$$X^e_{ij} = X_{ij} \frac{1/2 \ \Sigma_i(X_{ij}+M_{ij})}{\Sigma_i \ X_{ij}} \quad ; \quad M^e_{ij} = M_{ij} \frac{1/2 \ \Sigma_i(X_{ij}+M_{ij})}{\Sigma_i \ M_{ij}}$$

$$\Sigma_i \ X^e_{ij} = \Sigma_i \ M^e_{ij} = 1/2\Sigma_i \ (X_{ij}+M_{ij})$$

$$(6) \qquad Q_j = \frac{\Sigma_i(X_{ij}+M_{ij}) - \Sigma_i|X^e_{ij}-M^e_{ij}|}{\Sigma_i(X_{ij}+M_{ij})} \cdot 100$$

where X_{ij} and M_{ij} represent respectively the exports and imports of country j in industry i. Substituting the above expressions for X^e_{ij} and M^e_{ij} into (6), we obtain:

$$(7)\quad Q_j = \frac{\Sigma_i(X_{ij}+M_{ij}) - \Sigma_i \left| 1/2\Sigma_i(X_{ij}+M_{ij})\cdot\left(\frac{X_{ij}}{\Sigma_i X_{ij}} - \frac{M_{ij}}{\Sigma_i M_{ij}}\right)\right|}{\Sigma_i\ (X_{ij} + M_{ij})} \cdot 100$$

The above rather complicated expression can easily be simplified to obtain the following formula, which is in fact identical to that of an index used by Michaely in 1962:

$$(8)\qquad Q_j = 1-1/2\ \Sigma_i \left|\frac{X_{ij}}{\Sigma_i X_{ij}} - \frac{M_{ij}}{\Sigma_i M_{ij}}\right| \cdot 100$$

This index varies between 0 and 1. It is 1 when all the industries (or commodities) considered have the same weights in total exports as in total imports, because in this case $X_{ij}/\Sigma_i X_{ij}-M_{ij}/\Sigma_i M_{ij}$ is 0 for every i. The index reaches its minimum (zero) when imports and exports are concentrated in different industries (or commodities).

According to Aquino, this index has two advantages over the G-L one. Firstly, it avoids the problem of the correction for overall trade imbalance. Secondly, it is not dependent on the values of the expression $\Sigma_i |X_i-M_i|$, which, as will be shown below, makes the G-L measure dependent on the level of data aggregation.

Furthermore, Aquino correctly points out that this expression has the undesirable property of being equal to $|\Sigma_i X_i-\Sigma_i M_i|$ whenever either $X_i-M_i>0$ for all i, or $X_i-M_i<0$ for all i. In these circumstances, the G-L index of formula (5) attains its maximum value of 1, even if not all the trade of the country considered is of the intra-industry type.

The importance of this problem for empirical studies on IIT is not very great, however, because it occurs with a probability inversely related to the number of elementary items used when the G-L index is computed. It is extremely unlikely to arise with highly disaggregated data. For instance, constructing G-L indices for SITC 2-digit Divisions starting from 5-digit items implies that for each Division there are many elementary items. Consequently, $\Sigma_i |X_i-M_i|$ normally increases with the level of disaggregation of the data, so that the G-L index actually decreases, because the other terms in formulas (4) and (5) do not change with data disaggregation. In any case, this limitation only makes itself felt when the $\bar{C}_i$ index is used; if the "uncorrected" $\bar{B}_i$ index is employed the problem simply disappears. It is generated by the correction procedure. As I shall argue below, the $\bar{B}_i$ index is definitely to be preferred for the empirical analysis of IIT because the correction for trade imbalances has no theoretical justification.

As regards the desirability of the responsiveness of the G-L measure to the level of data aggregation, it is necessary to determine not only its origin, the above-noted variation of $\Sigma_i |X_i - M_i|$ with the level of data disaggregation, but also whether this characteristic is or is not linked to the intensitiveness of IIT. The latter issue can be illustrated by means of the following numerical example.[3]

Table 1

The Grubel and Lloyd index of intra-industry trade and the level of data aggregation: An example

Cases	Case 1		Case 2		Case 3	
Countries / Industries	A	B	A	B	A	B
1)	80	60	1a) 30	20	1a) 20	30
			1b) 50	40	1b) 60	30
2)	50	70	2) 50	70	2) 50	70
Total	130	130	130	130	130	130
G-L index uncorrected	85 %		85 %		77 %	

Note: The figures in the first three lines of the table represent the values of the exports from each country to the other; in the last line the percentage values of the G-L index are reported.

3. The example is constructed to avoid any complication caused by the "correction term", whose role has been discussed. Thus, the example refers to the $\bar{B}_i$ index. However, the problem we are discussing is linked to the term $\Sigma_i |X_i - M_i|$ and has nothing to do with the term $|\Sigma X_i - \Sigma M_i|$; the example therefore refers to the more general case.

In case 1, the trade of both country A and country B consists of the exchange of products of industries 1) and 2) and leads to a level of IIT which, when measured by the G-L $\bar{B}_i$ index, is equal to 85%. Cases 2 and 3 refer to a more detailed classification scheme with the first industry divided into two sub-sectors. When, as in case 2, the signs of the imbalances in each sub-sector are equal to the sign of the total imbalance, the measured level of IIT is the same as in case 1 (85%). By contrast, if, as in case 3, one country (country A) records a trade deficit in one of the two sub-sectors of industry 1) and a trade surplus in the other, the measured level of IIT falls to 77%. Since in this last case the extent of the trade overlap is obviously reduced, this seems a suitable property of the G-L index.

However, in my opinion, the final judgement about this feature of the index cannot be properly formulated unless due account is taken of the problem of the definition of an industry. If industry 1), for example, is defined so as to include two very heterogeneous sets of goods, produced under different production conditions, the classification adopted in case 1 would lead to an upward biased measure of the true level of IIT as a result of the incorrect category aggregation. Conversely, a sound definition, and hence a suitable choice of the industrial sectors in case 1, would make the split of industry 1) into two sub-sectors (in cases 2 and 3) appear incorrect, leading to an underestimation of the true level of IIT.[4]

In sum, although the responsiveness of the G-L $\bar{B}_i$ index to the level of data aggregation seems to be appropriate for measuring IIT, because the extent of trade overlap generally declines with disaggregation, it is of no help in guiding the decision on how to choose the level of data disaggregation that permits the correct identification of industrial sectors in terms of factors proportion and the end-use of the goods produced. A correct decision in this area is necessary to avoid confusion between inter-industry and intra-industry trade at the empirical level. However, the currently available statistical information on international trade and production makes it extremely difficult to solve the problem satisfactorily at the "scientific" level and recourse has to be made to subjective judgment

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4. This case supports Balassa's 1979 warnings against the use of an excessively disaggregated data-set.

(Vona, 1990).

4. The "need for correction argument" and its fallacies

We can now focus on the main criticism regarding G-L, i.e. Aquino's attack on the correction for total trade imbalance.

Let us refer again to (8), where the level of IIT is measured by the percentage sectorial composition of a country's imports and exports. Aquino, of course, solved the problem of the G-L index simply because the term $\Sigma_i |X_i - M_i|$ does not appear in the Q_j measure. This is done by breaking the link between the theoretical concept of IIT and the empirical one of trade overlap, in fact the "new" index refers to trade composition similarity rather than to trade overlap. However, it is hard to understand how this similarity is linked to IIT, and there is no clarification on this point in Aquino's work. Indeed, this index was originally designed by its inventor (Michaely, 1962; pp. 87-92) to measure similarities of import and export structures rather than IIT: the more similar those structures, the higher the value of the index.

The rather loose, and even contradictory, link between IIT and the composition similarity of trade flows measured by the Michaely-Aquino (henceforth M-A) index can easily be shown by means of the following numerical example.

Table 2 below presents four situations (cases) for a country which has three industries and takes part in international trade. The four situations appear very different, even at a first glance: for a given level of exports, imports increase greatly from case 1 to case 4. Nonetheless, the value of Aquino's index is the same in all four cases (60). This happens because the shares of each industry's exports in total exports and of each industry's imports in total imports do not change. It is quite evident that the level of IIT, as proxied by trade overlap, is not equal in the four cases, but tends to decline from case 1 to case 4, a feature which is reflected in the values of the G-L $\bar{B}_i$ indices. Moreover, at an elementary level, the M-A index produces the quite astonishing result of measuring an equal level of IIT in industry 3) in case 1, where it exports 10 units and imports 50, and in case 4, where it exports 10 units and imports 120:

Table 2

Some shortcomings of the Michaely-Aquino index for measuring IIT. A numerical example

Cases	Case 1		Case 2		Case 3		Case 4	
Trade / Industries	X	M	X	M	X	M	X	M
1)	50	40	50	80	50	88	50	96
2)	40	10	40	20	40	22	40	24
3)	10	50	10	100	10	110	10	120
Total	100	100	100	200	100	220	100	240
	percentage values							
M-A	60		60		60		60	
G-L not corrected for trade imbalance	60		53		51		49	

this measure of IIT at an elementary level is therefore totally unrelated to the pattern of trade flows which actually take place at that specific level, but depends entirely on the inter-sectoral composition of trade. Hence, Aquino's criticism of the G-L B_i elementary measure does not lead to any improvement.

In sum, the M-A measure solves one problem of the G-L index (the dependence on the level of data aggregation), but it presents some logical inconsistencies and practical shortcomings which suggest that it is not a suitable tool for measuring IIT.

The above discussion brings us back to the original issue of correcting the G-L index for the overall trade imbalance, which underlies most of the problems examined up to this point.

The correction of the $\bar{B}_i$ index in formula (4) for the total trade imbalance has been justified by the need to allow it to reach its maximum value (100) even when, as very often happens, total trade is not balanced. This argument does not appear correct or even justifiable, and I find it difficult to catch the point. In fact, when trade is balanced at an elementary level, that is when the B_i are all equal to 100, the $\bar{B}_i$ index does correctly attain its maximum value. Why should it also reach this value when trade is not balanced? Indeed, it is not the total aggregate imbalance which is "reflected" in the imbalances at a more disaggregate level, as Aquino assumes. On the contrary, these imbalances are precisely the reason why an aggregate imbalance does emerge. It is true that the value of $\Sigma_i |X_i - M_i|$ is usually greater than that of $|\Sigma_i X_i - \Sigma_i M_i|$, but this is simply because in measuring trade overlap the signs of the elementary imbalances are not relevant.

Furthermore, it seems rather awkward to divide total trade into three different parts and (as noted in section 2) to consider one of these parts (the trade imbalance) as a disturbing factor which has to be removed. Behind the idea of using an index of IIT which refers to a situation of balanced trade lies the conviction that the empirical measure must be able to reflect an important standard property of the theoretical models of international trade, i.e. that trade flows must be balanced in long-run equilibrium. However, care needs to be taken when transferring properties of the theoretical sphere into the empirical world. In fact, most of the empirical works on IIT, including Aquino's, refer to the manufacturing sector. There is obviously no theoretical justification for imposing balanced trade in manufacturing on each country considered, because one country may well run a deficit in the manufacturing sector, even for a long period, while earning surpluses on its trade in other sectors (agriculture, mining, services). This is all the more true if one considers bilateral trade relations. Thus, the equilibrium condition is correctly imposed upon an IIT measure only if it refers to the total trade in goods and services between one country and the rest of the world (disregarding the role of capital flows for the sake of simplicity).

Moreover, the claim in the "need for correction argument" that correction is necessary at the most elementary level of disaggregation is even more unconvincing, at least in Aquino's version. There is absolutely no justification for this on either theoretical or empirical grounds. For example, it is really hard to imagine why France's foreign trade with Italy in "machinery for manufacturing or finishing of felt" (SITC1 group 717.14) or "electric shavers and hair clippers" (SITC1 725.04) should be balanced, and moreover, how imbalances in these product groups could eventually give rise to macroeconomic reactions leading to equilibrium.

The distortions which emerge from the approach I have criticized are evident in the empirical literature. Loertsher and Wolter (1980) and Bergstrand (1983) have pushed this approach further and corrected trade in sub-sectors of the manufacturing industry on a bilateral basis.[5] The first of these articles uses the method proposed by Aquino, while the second develops a new one which is worth discussing here.[6]

Bergstrand ignores Aquino's index and proposes an iterative procedure for adjusting bilateral disaggregated trade flows in order to make them consistent with the multilateral aggregate trade balance. The index adopted is the following:

$$(9) \qquad IIT^k_{ij} = 1-[\,|X^{k*}_{ij}-X^{k*}_{ji}|/(X^{k*}_{ij}+X^{k*}_{ji})]$$

where:

$$X^{k*}_{ij} = 1/2\ [(X_{i.}+M_{.i})/2X_{i.}+(X_{j.}+M_{.j})/2M_{.j}]\ X^k_{ij}$$

$$X^{k*}_{ji} = 1/2\ [(X_{j.}+M_{.j})/2X_{j.}+(X_{i.}+M_{.i})/2M_{.i}]\ X^k_{ji}$$

$$X_{i.} = \Sigma_k\Sigma_j\ X^k_{ij} \qquad M_{.i} = \Sigma_k\Sigma_j\ X^k_{ji}$$

$$X_{j.} = \Sigma_k\Sigma_i\ X^k_{ji} \qquad M_{.j} = \Sigma_k\Sigma_i\ X^k_{ij}$$

" X^k_{ij} (X^k_{ji}) is the value of the actual trade flows in industry k from country i to country j (j to i). Computing X^{k*}_{ij} (X^{k*}_{ji}) iteratively until some convergence criterion is met ... yields bilateral trade flows for the k^{th} industry that are simulated to reflect multilateral aggregate trade balance" (p. 209).

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5. A sound criticism of this approach was put forward by Greenaway and Milner (1981): "There can be no a priori justification, however, for approximating 'equilibrium' with multilateral balance on manufactured trade, and certainly not with matching of manufactured goods on a bilateral basis. We can only confidently state that the particular characteristics and inheritances of an economy mean that 'equilibrium' can be compatible with imbalance on any particular set of international transactions including trade imbalance on manufactured goods" (pp. 257-258).

6. Luckily, as we shall see below, in both of these studies some kind of uncorrected G-L index is employed and its results extensively reported and commented upon.

Working with this formula to derive the properties of Bergstrand's index would be rather complicated and time consuming. The example proposed by Bergstrand himself (pp. 60-61) is a very helpful short cut because it allows the reader to judge the index from the results it produces.

In the multilateral 3-country/2-industry world considered by Bergstrand, the balancing of aggregate trade flows in each country actually takes place: (a) by reducing the surplus of country 3; (b) by reducing the deficits of countries 1 and 2 accordingly; and (c) by redistributing these deficits between them so that the two countries tend to have the same deficit. This last feature of the adjustment procedure, which is rather awkward -- appears very clearly in Bergstrand's example. In fact, while country 1's deficit in the starting (real world) situation is double that of country 2, after the first iteration, the ratio is reduced to 1.52, and it falls to 1.35 after the second iteration (where the example ends).

This result suggests that the relative positions of the countries are profoundly changed in the new artificial world of balanced trade.[7] Hence, this kind of correction has no more appeal than that proposed by Aquino. Both are dominated by arbitrary procedures from the empirical point of view, and neither possesses any clear link with the theory of international trade.

However, Bergstrand's work has one merit:[8] by increasing the family of corrected indices, it shows that the set of correction procedures can be extended indefinitely without anyone being able to show the superiority of one over the other.

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7. A further disappointing feature of the procedure proposed by Bergstrand, and exemplified in the empirical part of the paper, is that it imposes an equilibrium of multilateral trade in a particular industry for each country within the sample of 14 industrial countries considered. This equilibrium, therefore, applies not only to the trade of a narrowly defined industry level, but also to each country on a bilateral basis within a limited, even if representative, sample of 13 other industrial countries.

8. We refer here only to the measurement problem and not to other aspects of this study.

5. Grubel and Lloyd's uncorrected index as a suitable measure of intra-industry trade

It is clear from the above discussion that the "need for correction argument" is theoretically unsound and leads to unreliable adjustment procedures. Moreover, the uncorrected G-L $\bar{B}_i$ index possesses various attractive features.

First, as we have seen earlier, it does not suffer from the problem of reaching the maximum, which arises with the $\bar{C}_i$ measure, simply because in some circumstances $\Sigma_i |X_i - M_i|$ is equal to $|\Sigma_i X_i - \Sigma_i M_i|$, irrespective of the behaviour of X_i and M_i.

Second, and more important, it seems to perform much better than other indices, as can be seen by looking at the example considered above, in which Aquino's index always assumed the same value (60), and calculating the values of the G-L index, both corrected and uncorrected. The results are shown in Table 3 below.

Table 3

Application of Grubel and Lloyd's indices to the example of Table 2
(percentage values)

Cases / Indices	Case 1	Case 2	Case 3	Case 4
G-L uncorrected	60	53	51	49
G-L corrected	60	80	82	84

Thus, correcting for total imbalance leads to an index which not only produces higher values than the uncorrected one but also behaves very differently across the four cases considered, indicating an increase in IIT while the uncorrected index indicates a reduction.

Indeed, the above example suggests that the more plausible values are actually generated by the uncorrected G-L index. In fact, case n (n = 2,..4) differs from case n-1 only because imports have been increased proportionately in each industry. The level of IIT should therefore fall between the first and the last case, because the trade overlap has decreased. This is rightly rendered by the uncorrected index, but not by the corrected one. The latter index increases, reflecting the fact that the decrease in trade overlaps leads to an increase in the numerator while the denominator remains unchanged: in each case, in fact, overall balanced trade is equal to 200.

It is worth noting that the uncorrected G-L measure also avoids the problem referred to in section 2 of dividing total trade flows into three parts, of which one, the trade balance, is viewed as a disturbing factor which cannot be classified as either intra- or inter-industry trade. The uncorrected G-L index divides all trade flows into two categories, inter- and intra-industry. As I argued above, correction for the trade balance raises more empirical problems than it solves and does not present any clear link with theoretical considerations, which on the contrary argue against the adjustment, especially when the calculations are confined to the manufacturing sector and, even more so, when bilateral trade is considered. Hence, I am inclined to conclude that the uncorrected G-L measure is the best available and, on the whole, possesses desirable properties.[9]

6. A new index?

In this article I have focused on the issue of measuring IIT, neglecting the other important issue, referred to in the introduction, of properly defining "industries" and singling them out at the empirical level. I have discussed this issue in detail in a recent paper (Vona, 1990); on the

9. Finger (1975) expressed his preference for an uncorrected index in the following statement, which gives further support to the "anti-correction argument": "Grubel and Lloyd's primary measure of 'intra-industry trade' involves an adjustment for trade imbalance. But if the results are to be used to evaluate the validity of the factor proportions theory or any other theory, the unadjusted measure is preferable. Any adjustment contains implicit assumptions about the effect on trade patterns of eliminating the phenomena being adjusted for, hence the 'adjusted' figures could be misleading because of the invalidity of these implicit assumptions" (p. 586, footnote 4).

basis of the analysis undertaken there I have developed the idea that the two problems are strictly interrelated. In particular, if the problem of correctly defining, and empirically identifying, the industries for which IIT should be calculated is satisfactorily dealt with, the problem of the measure to be adopted changes perspective.

In fact, at an elementary industry level, it is meaningless to use an index which divides trade flows into two parts, inter-industry and intra-industry trade, as the G-L B_i index requires; at that finely disaggregated level of trade data, all trade should be classified either as intra-industry or as inter-industry, depending on whether there is some two-way trade or not. In other words, the existence of two-way trade at the most disaggregated industry level -- the 4 or the 5-digit SITC categories -- justifies considering all that trade as IIT, regardless of whether there is an imbalance. Indeed, it is the existence of the simultaneous exchange of very similar goods produced under very similar conditions which constitutes IIT, the existence of an imbalance is irrelevant.

According to this approach, there are only two types of industry: one is characterized by economies of scale, product differentiation and imperfect competition and tends to give rise only to IIT, the other is the homogeneous product, perfect competition industry of the H-O-S model, which can only produce inter-industry trade. No intermediate situation should be considered. In this setting the link between the empirical notion of trade overlap and the theoretical definition of IIT is broken. Accordingly, the measure of IIT to be adopted would be the following (for the bilateral exports between country A and country B in industry i):

$$I_{A,B,i} = X_{A,B,i}+X_{B,A,i} \quad \text{if both } X_{A,B,i} \text{ and } X_{B,A,i} \neq 0 \tag{10}$$

$$I_{A,B,i} = 0 \quad \text{if either } X_{A,B,i} \text{ or } X_{B,A,i} \text{ is equal to zero.}$$

The value of $I_{A,B,i}$ measures the amount of inter-industry trade in industry i.

For an industry at an elementary level, $I_{A,B,i}$ is not an index; it cannot generate percentage values but only absolute amounts in dollar terms. An index can be calculated at a higher level of aggregation: if one uses the 5-digit SITC categories as elementary industries, they can be re-grouped, at the 3-digit level, for example. The following index can then be calculated (where j indicates the 3-digit sector and i the 5-digit industries within that sector, for each given j):

$$(11) \qquad IIT_{A,B,j} = \frac{\Sigma_i \, I_{A,B,i}}{(X_{A,B,j}+X_{B,A,j})} \cdot 100 \qquad \forall i \; I_{A,B,i} \neq 0$$

This index, which varies between 0 (no IIT, all $I_{A,B,i}$=0) and 100 (all trade is intra-industry), reflects the theoretical approaches to both intra-industry and inter-industry trade quite closely. Moreover, it is not affected by the need to correct for trade imbalance, nor is it excessively responsive to the level of data disaggregation. It may nonetheless appear paradoxical that, when applied to the four cases of the example in table 2, the new index always has the same value, i.e. its maximum (100), a feature I have criticized in connection with the M-A index. However, since trade overlap is excluded in the conceptual framework within which the new index is elaborated and only "pure" intra and inter-industry trade are considered, this feature should now not be viewed as a shortcoming of the new index. While I have still to examine the statistical properties of this index thoroughly, some preliminary calculations are reported here, referring to the bilateral trade in 1987 of a sample of OECD countries (USA, Germany, France, Italy, Belgium, Spain, Greece, Portugal, Sweden, Austria and Yugoslavia) in the manufacturing sector and in six industries within this sector: medical and pharmaceutical products, glass and glassware, agricultural machinery and implements, textile machinery, domestic electrical equipment, and railway vehicles. The results are shown in Tables 4-11, while Table 12 shows the uncorrected G-L indices for manufacturing industry, which are included for the sake of comparison.

Examining the new indices for the whole of manufacturing industry (Table 4) shows clearly that, on average, their values are considerably higher than those of the uncorrected G-L index (Table 12). For 66 bilateral values, the new index is above 90 per cent in 40 cases (60 per cent of the total), while it is below 20 per cent only in 8 cases (12 per cent). It is also evident that the higher values are achieved in trade between neighbouring countries at similar stages of development and with low trade barriers, as shown by the indices of bilateral IIT among the five EEC countries with the highest per capita incomes (Germany, France, the UK, Italy and Belgium), which always attain values above 95 per cent. These results are in contrast with those of the uncorrected G-L index, whose values are above 60 per cent in only 3 cases and below 20 per cent in 32 cases. Consequently, the skewness of the frequency distributions of the two IIT indices is sharply different: it is negative, with a coefficient of -1.32, for the new index and it is positive, with a coefficient of 0.39, for the uncorrected G-L index. Nonetheless, the results which are achieved with the two indices are, on the whole, not very different as revealed by the value of the correlation coefficient (0.73).

Overall, I view the results of the new index as quite reasonable, considering that the sample consists of highly developed industrial countries and refers only to manufactured goods. In this setting, two-way trade is the rule and not the exception, so that high values of IIT are to be expected. Indeed, what is surprising is that bilateral IIT between the US and Germany and the US and Italy, is below 30 per cent, according to the G-L measure.

As far as the results for the six industries are concerned (Tables 5-10), it appears that the new index reaches its extreme values quite easily, again in contrast with the G-L index, so that the frequency distribution of the measured bilateral IIT, in the same sample of countries, is rather polarized. In particular, the maximum (100) is attained in a large number of cases (26) for the industries producing domestic electrical equipment and textile machinery, while the minimum is achieved most frequently in the railway vehicle industry (8 cases).[10] The ability of the new index to achieve its maximum in a number of cases is certainly a suitable characteristic and represents an advance on the uncorrected G-L index, which attains its maximum value only in very special circumstances (as shown in section 2). However, although the sample of industries considered is very small (6 industries), it seems that the new index is not free from the problem of being dependent on the number of elementary items (commodity groups) included in each industry. In other words, as the number

10. The number of minimum values in each industry does not include the cases of no bilateral trade between the countries concerned.

of elementary items increases, the likelihood of the new index recording high values diminishes: in fact, the three industries with the smallest number of commodity groups (domestic electrical equipment, 5; textile machinery, 6; agricultural machinery, 6) do show the highest number of maximum values of the index (26, 26 and 19 respectively). More research work is required on this aspect of the new index. Nonetheless, some further insight into this problem can be derived from the comparison of the IIT indices calculated for the domestic electrical equipment industry with SITC1 data (5 elementary items, Table 10) and those calculated, for the same industry, with SITC2 data (17 elementary items, Table 11). The latter indices are always found to be smaller than or equal to the former: the tendency of measured IIT to fall with the number of elementary items is thus confirmed.

7. Conclusions

This article presents an analysis of the issue of measuring IIT. It first examines the pros and cons of the "need for correction argument", according to which indices for measuring IIT must be corrected for the trade imbalance, and concludes that it should be rejected on both theoretical and empirical grounds. In particular, it is shown that the corrections proposed in the literature are highly arbitrary and unrelated to any theoretical foundation. As a consequence, the uncorrected G-L index has been found to be the best of those currently available. It is nonetheless rather responsive to the level of data disaggregation, whose optimal level is difficult to determine empirically and which also depends on the proper definition of industries.

Unfortunately, international trade data suffer from limitations which prevent the achievement of a fully scientific solution of the problem. Nonetheless, a large body of empirical evidence, including that put forward in this paper, seems to point to the 4-5 digit level of SITC disaggregation as the most appropriate for measuring IIT. Even with these highly disaggregated data, IIT computed on a bilateral basis is quite sizeable, especially as measured by the new index of IIT proposed here. The crucial characteristic of this index is that it is derived from theoretical considerations and is not linked to trade overlap but directly reflects the concept of IIT. However, its empirical behaviour needs to be further investigated. Some results obtained with the new index are reported; they show that the new index leads to plausible values of bilateral IIT and that it possesses some desirable properties, though the problem of responsiveness to the number of elementary items considered is not solved. In sum, it is premature to state that the new index is definitely superior to the existing ones, but it may represent a valid alternative in many circumstances.

Table 4

NEW INDICES OF IIT, TOTAL MANUFACTURING INDUSTRY (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.	YUG
U.S.	..	96.6	92.3	95.0	96.9	73.3	96.5	91.6	85.5	93.5	93.9	15.6
Japan		..	94.9	92.8	98.8	10.8	82.3	91.5	88.8	92.9	98.6	6.0
Belgium			..	99.8	99.4	65.1	95.1	99.5	94.5	92.8	98.3	31.3
France				..	99.4	68.6	96.0	99.9	99.3	95.5	97.3	14.0
Germany					..	91.8	96.3	99.7	99.0	94.7	97.9	35.1
Greece						..	15.9	78.7	48.6	59.3	67.8	52.9
Ireland							..	92.1	76.4	76.2	99.5	10.2
Italy								..	98.3	94.3	98.4	48.2
Spain									..	88.2	93.6	17.6
Sweden										..	94.4	11.2
U.K.											..	26.9
Yugosl.												..

Note: 5-digit SITC1 items are used in the calculations. Divisions 5-8 are considered.

Table 5

NEW INDICES OF IIT, SITC1 541 MEDICAL AND PHARMACEUTICAL PRODUCTS (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	99.9	99.9	97.9	100.0	24.0	99.9	98.7	95.3	82.8	99.1
Japan		..	90.8	98.2	98.6	39.9	21.4	96.2	98.3	98.8	99.9
Belgium			..	100.0	100.0	69.5	97.7	100.0	98.9	50.6	99.9
France				..	100.0	65.0	100.0	100.0	99.3	51.0	100.0
Germany					..	78.6	99.3	100.0	100.0	49.6	100.0
Greece						..	38.4	86.3	22.2	0.0	69.7
Ireland							..	91.3	94.3	0.0	100.0
Italy								..	98.9	82.1	99.9
Spain									..	84.7	96.3
Sweden										..	49.0
U.K.											..

Table 6

NEW INDICES OF IIT, SITC1 717 TEXTILE MACHINERY (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	100.0	99.8	100.0	100.0	39.3	100.0	100.0	100.0	100.0	100.0
Japan		..	99.9	99.6	100.0	0.0	16.5	99.9	85.7	100.0	100.0
Belgium			..	100.0	100.0	11.8	69.5	99.9	100.0	96.5	99.5
France				..	100.0	2.0	52.2	100.0	100.0	97.8	100.0
Germany					..	100.0	100.0	100.0	100.0	100.0	100.0
Greece						..	n.t.	100.0	87.2	22.1	48.6
Ireland							..	22.0	12.3	99.7	99.6
Italy								..	99.8	98.9	100.0
Spain									..	95.3	99.5
Sweden										..	99.9
U.K.											..

Note: n.t. = no trade.

Table 7

NEW INDICES OF IIT, SITC1 712 AGRICULTURAL MACHINERY AND IMPLEMENTS (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	100.0	100.0	99.6	98.9	0.0	50.5	98.6	43.0	100.0	100.0
Japan		..	98.6	99.8	98.0	0.0	0.4	99.7	0.0	65.3	99.4
Belgium			..	100.0	100.0	8.0	74.2	100.0	99.5	100.0	100.0
France				..	100.0	43.4	98.1	100.0	100.0	99.9	100.0
Germany					..	78.8	79.0	100.0	99.6	100.0	100.0
Greece						..	n.t.	52.3	0.0	0.0	5.0
Ireland							..	83.8	0.0	98.6	100.0
Italy								..	100.0	99.8	100.0
Spain									..	89.3	99.7
Sweden										..	99.9
U.K.											..

Note: see table 6.

Table 8

NEW INDICES OF IIT, SITC1 664+665 GLASS AND GLASSWARE (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	99.3	99.2	100.0	99.8	72.9	100.0	99.6	93.5	78.2	93.2
Japan		..	63.9	98.9	99.4	91.8	22.0	93.0	80.1	24.0	60.0
Belgium			..	100.0	99.3	0.0	65.1	99.6	95.3	60.8	99.5
France				..	100.0	4.9	98.6	100.0	100.0	92.0	94.2
Germany					..	6.3	96.7	99.8	94.7	85.7	84.7
Greece						..	n.t.	11.3	0.0	0.0	47.1
Ireland							..	66.8	78.2	75.9	98.7
Italy								..	99.9	83.3	96.6
Spain									..	53.9	99.0
Sweden										..	88.1
U.K.											..

Note: see table 6.

Table 9

NEW INDICES OF IIT, SITC1 731 RAILWAY VEHICLES (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	57.0	100.0	30.9	80.1	0.0	61.7	98.7	93.2	99.9	99.0
Japan		..	n.t.	100.0	99.7	n.t.	n.t.	23.4	0.0	0.0	39.3
Belgium			..	100.0	98.7	n.t.	97.7	53.6	100.0	100.0	100.0
France				..	98.4	0.0	68.0	85.9	87.7	84.9	25.9
Germany					..	90.9	100.0	99.8	99.5	94.7	97.3
Greece						..	n.t.	0.0	0.0	n.t.	0.0
Ireland							..	n.t.	n.t.	n.t.	99.2
Italy								..	87.4	77.3	92.2
Spain									..	0.0	66.5
Sweden										..	95.1
U.K.											..

Note: see table 6.

Table 10

NEW INDICES OF IIT, SITC1 725 DOMESTIC ELECTRICAL EQUIPMENT (1987)
(percentage values)

Countries	U.S.	Japan	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	100.0	91.9	99.7	100.0	0.0	98.5	100.0	99.7	99.5	100.0
Japan		..	89.9	100.0	98.9	0.0	95.6	90.6	85.6	100.0	100.0
Belgium			..	100.0	100.0	72.0	97.7	100.0	100.0	99.9	100.0
France				..	100.0	49.2	80.1	100.0	100.0	100.0	100.0
Germany					..	99.8	98.7	100.0	100.0	100.0	100.0
Greece						..	0.0	66.2	47.7	93.0	94.2
Ireland							..	88.1	73.3	81.5	100.0
Italy								..	99.9	100.0	100.0
Spain									..	100.0	100.0
Sweden										..	99.9
U.K.											..

Note: 5 elementary items are considered (SITC1).

Table 11

NEW INDICES OF IIT, DOMESTIC ELECTRICAL EQUIPMENT (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.
U.S.	..	97.2	51.1	94.6	85.9	0.0	96.2	49.2	93.6	98.0	90.4
Japan		..	82.4	99.0	98.7	0.0	0.0	72.3	63.9	94.2	99.1
Belgium			..	100.0	100.0	56.1	30.5	99.8	98.2	89.8	100.0
France				..	100.0	35.3	64.6	95.3	100.0	98.8	100.0
Germany					..	82.5	98.4	98.4	99.8	98.2	100.0
Greece						..	0.0	44.5	47.6	10.9	29.6
Ireland							..	62.6	30.8	54.0	100.0
Italy								..	88.5	98.5	94.6
Spain									..	63.7	100.0
Sweden										..	99.7
U.K.											..

Note: 17 elementary items are considered (SITC2).

Table 12

G-L INDICES OF IIT, NOT CORRECTED FOR TRADE IMBALANCES; TOTAL MANUFACTURING INDUSTRY (1987)
(percentage values)

Countries	U.S.	JAP	BEL	FRA	GER	GRE	IRE	ITA	SPA	SWE	U.K.	YUG
U.S.	..	16.4	26.0	43.0	28.4	7.9	33.1	29.5	17.1	30.3	47.8	3.8
Japan		..	8.9	19.9	40.0	0.7	16.6	22.5	7.2	18.6	18.3	3.5
Belgium			..	54.9	63.1	14.7	18.1	37.1	37.8	25.5	49.5	4.8
France				..	60.4	17.0	21.5	51.5	47.6	38.9	67.1	3.1
Germany					..	13.1	50.1	48.1	42.7	38.8	49.2	7.0
Greece						..	7.9	16.4	10.0	9.8	13.1	18.6
Ireland							..	20.4	12.4	17.6	49.7	1.6
Italy								..	42.0	40.6	46.5	15.8
Spain									..	24.6	39.3	2.0
Sweden										..	37.7	1.8
U.K.											..	7.0
Yugosl.												..

Note: 5-digit SITC1 items are used in the calculations.

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