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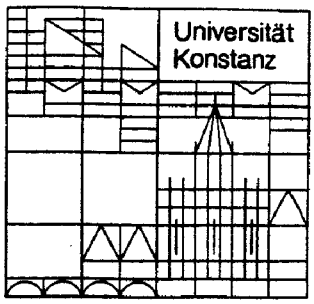

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TRADE OVERLAP AND TRADE PATTERN INDICES OF INTRA-INDUSTRY TRADE: THEORETICAL DISTINCTIONS VERSUS EMPIRICAL SIMILARITIES

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Abstract

In a recent survey of intra-industry trade indices Kol and Mennes (1986) suggested to make a basic distinction between the study of matching trade flows and that of the similiarity of trade patterns. The present paper shows that in both cases measures of intra-industry trade may be expressed either as *distances* or as *equality* indices, and derives the corresponding families of intra-industry indices. An empirical section indicates however that despite these theoretical distinctions, most of the intra-industry trade indices are highly correlated.

1 Introduction

Intra-industry trade occurs when goods which are produced by a single industry are exported as well as imported by a country. Trade among industrialized countries is in fact to a large extent intra- industry trade (Greenaway/Milner [1986]). In recent works consumer preferences for product diversity and economies of scale in the production of many goods have been emphasized (Helpman/Krugman [1985]), to explain this fact. Important policy implications have also been stressed since, for example, the adjustment to structural changes might be easier when intra- industry trade specialization is prevailing.[1] A prerequisite however to the analysis of these questions is to measure correctly intra-industry trade.

In a recent survey of the various ways of measuring intra-industry trade (Kol/Mennes [1986]) a distinction has been proposed between two main areas of analysis: the study of *matching trade flows* and that of the *similarity of trade patterns*. Relevant measures appearing in the literature have then been recommended for each of these two fields of research. These are, for example, the Grubel/Lloyd index which measures the amount of overlapping *trade flows* and the Michaely/Aquino index which measures the *similarity of trade shares*.

The analysis of *trade flows* would be preferred in those cases, where the actual amount of trade is relevant (e.g. effects of trade on unemployment or on the balance of trade, effects of protection, etc). The analysis of *trade patterns* would rather concern studies of comparative advantages, effects of market integration, etc..

The purpose of this paper is to take another look at this distinction. It will be proven in *section 2* that the measures of Grubel/Lloyd and Michaely/Aquino may be both considered as *distance* concepts. Since there are

[1] See also Giersch [1979], Tharakan [1983].

several ways of defining a distance, a whole family of trade overlap as well as of similarity in trade patterns indices may be derived.

In *section 3* it will be shown that Grubel/Lloyd type indices (which look at matching trade flows) and Michaely/Aquino type indices (which analyze the similarity of trade patterns) may be also expressed as measures of *equality*. As on the one hand a different kind of equality is taken into account in each case and, on the other hand, several ways of measuring equality exist, two families of intra-industry trade indices are obtained again.

The contrast between these two categories of intra-industry trade indices is, however, not as strong as one may think. Despite the fact that the Grubel/Lloyd and the Michaely/Aquino indices measure different kinds of distances or equalities, it will be shown in *section 4* that they will often display similar values. An empirical investigation presented in *section 5* confirms that there is quite a strong connection not only between these two indices but, more generally, between all the intra-industry indices which were derived in the previous sections.

2 Intra-Industry Trade Indices as Measures of Distance

Let X_i and M_i be respectively the amount of exports and imports of industry i. The Grubel/Lloyd index [1975] of intra-industry trade (GL) is defined as[2]

$$\begin{aligned} \text{GL} &= 1 - \frac{\sum_{i=1}^{n} \mid X_i - M_i \mid}{\sum_{i=1}^{n} (X_i + M_i)} \\ &= 1 - \frac{\sum_{i=1}^{n} \mid X_i - M_i \mid}{max\{\sum_{i=1}^{n} \mid X_i - M_i \mid\}} \quad , \end{aligned} \tag{1}$$

[2]For simplicity all indices will be defined over the interval of [0,1] and not of [0,100].

since for a given level of $\sum_{i=1}^{n} X_i$ and $\sum_{i=1}^{n} M_i$ the sum $\sum_{i=1}^{n} \mid X_i - M_i \mid$ is greatest when only one industry exports and only one industry (another one) imports.[3]

Let P_X be the representation in a space of dimension n of the set $\{X_1, \cdots X_n\}$, P_M being the corresponding representation of the set $\{M_1, \cdots, M_n\}$. It can be seen that $\sum_{i}^{n} \mid X_i - M_i \mid$ is one of the ways of measuring the distance between the points P_X and P_M so that the GL index may also be written as

$$\mathrm{GL} = 1 - \frac{d(P_X, P_M)}{max[d(P_X, P_M)]} \quad , \tag{2}$$

where $d(P_X, P_M)$, the distance between P_X and P_M, is measured as $\sum_{i=1}^{n} \mid X_i - M_i \mid$.

A more general representation of the distance between P_X and P_M would be the expression

$$d^q(P_X, P_M) = \{\sum_{i=1}^{n} \mid X_i - M_i \mid^q\}^{1/q} \quad , \tag{3}$$

so that a generalization of the Grubel/Lloyd index could be written as

$$\mathrm{GL}^q = 1 - \frac{[\sum_{i}^{n} \mid X_i - M_i \mid^q]^{1/q}}{[X^q + M^q]^{1/q}} \quad , \tag{4}$$

where $X = \sum_{i=1}^{n} X_i$ and $M = \sum_{i=1}^{n} M_i$ and $q \geq 1$, since, for given levels of X and M, $max\{\sum_{i=1}^{n} \mid X_i - M_i \mid^q\} = X^q + M^q$. The case where $q = 2$ would

[3]The Balassa index [1974] B which is defined as

$$B = 1 - \frac{1}{n} \sum_{i=1}^{n} \frac{\mid X_i - M_i \mid}{(X_i + M_i)} \quad ,$$

measures, like the Grubel/Lloyd index GL, the amount of trade overlap. At the difference of the GL index, B gives the same weight to all industries. Since, as will be seen, the Michaely-Aquino index MA is also a weighted index, this paper will be limited to a comparison of the GL and MA indices.

give a representation of the generalized Grubel/Lloyd index in terms of the euclidean distance between P_X and P_M.

Another index is commonly used in intra-industry trade studies. It could be called the Michaely/Aquino (MA) index since Pomfret [1981] proved the equivalence between an index originally proposed by Michaely [1962] and an index suggested by Aquino [1978] to correct the Grubel/Lloyd index in the case of overall trade imbalance. The MA index may be written as

$$\text{MA} = 1 - \frac{1}{2} \cdot \sum_{i=1}^{n} \mid (X_i/X) - (M_i/M) \mid \quad . \tag{5}$$

Let x_i and m_i be, respectively, the shares in total exports and imports of industry i. Furthermore, let S_X and S_M be, respectively, the representation in a space of n dimensions of the set of shares $\{x_1, \cdots, x_n\}$ and $\{m_1, \cdots, m_n\}$. It can be seen that expression (5) may also be written as

$$\text{MA} = 1 - \frac{d(S_X, S_M)}{max[d(S_X, S_M)]} \quad , \tag{6}$$

where $d(S_X, S_M) = \sum_{i=1}^{n} \mid x_i - m_i \mid$, since $max\{\sum_{i=1}^{n} \mid x_i - m_i \mid\} = 2$ (this is again the case where only one industry exports and only one, a different one, imports).

A generalization of (6) could be written as [4]

$$\text{MA}^q = 1 - \frac{d^q(S_X, S_M)}{max[d^q(S_X, S_M)]} = 1 - \frac{[\sum_{i=1}^{n} \mid x_i - m_i \mid^q]^{(1/q)}}{2^{(1/q)}} \quad , \tag{7}$$

where $d^q = [\sum_{i=1}^{n} \mid x_i - m_i \mid^q]^{(1/q)}$. [5]

[4] Such a generalization was suggested by Berrebi/Silber [1988] in a study of export similarities. Their suggestion was an extension of the indices used by Finger/Kreinin [1979], Pomfret [1981] and Kellman/Schroder [1983].

[5] When euclidean distances are used, (7) becomes

$$\text{MA}^2 = 1 - \frac{\sqrt{\sum_i^n \mid x_i - m_i \mid^2}}{\sqrt{2}}$$

The comparison of (4) and (7) clearly shows the difference, justly emphasized by Kol/Mennes [1986], between indices measuring *trade flows overlap* ((4)) and those measuring the *similarity* of export and import *patterns* ((7)). In the first case the relevant distance $d^q(P_X, P_M)$ is a representation of the *amount* of trade overlap existing in all the industries. In the second case the distance used is $d^q(S_X, S_M)$ which measures the similarity between the export and import *shares*. In both cases a normalization is then made by dividing the actual distance by its maximal potential value. The next section will show that the GL and MA index may also be given an alternative interpretation, which will define them as *equality* indices.

3 Intra-Industry Trade Indices as Measures of Equality

It can been seen from (1) that the GL index is

$$\mathrm{GL} = 1 - \sum_{i=1}^{n} \{ \frac{(X_i + M_i)}{\sum_{i=1}^{n}(X_i + M_i)} \cdot \frac{\mid X_i - M_i \mid}{(X_i + M_i)} \} \quad .$$

Let t_i be equal to the weight $(X_i + M_i)/\sum_{i=1}^{n}(X_i + M_i)$ with $\sum_{i=1}^{n} t_i = 1$. Since $\mid X_i - M_i \mid /(X_i + M_i)$ is equal to the relative mean deviation d_i of the set $\{X_i, M_i\}$, (1) may be written as [6]

$$\mathrm{GL} = 1 - \sum_{i=1}^{n} t_i \cdot d_i \quad . \tag{8}$$

Let e_i be equal to $(1 - d_i)$. In other words, e_i is a measure of equality relevant to the couple $\{X_i, M_i\}$.[7]

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[6] The relative mean deviation of the set $\{X_i, M_i\}$ is defined as $\frac{0.5(|X_i-(X_i+M_i)/2|)+|M_i-(X_i+M_i)/2|)}{(X_i+M_i)/2} = \frac{|X_i-M_i|}{(X_i+M_i)}$.

[7] Since $d_i = \mid X_i - M_i \mid /(X_i + M_i)$ so that $0 \leq d_i \leq 1$, one may define an equality measure as $e_i = (1 - d_i)$ with $0 \leq e_i \leq 1$.

Then it follows that the GL index is given by

$$\mathrm{GL} = \sum_{i=1}^{n} t_i \cdot e_i \quad . \tag{9}$$

Equation (9) indicates that GL is a weighted average of the equality indices relevant to each couple $\{X_i, M_i\}$, the weight of industry i being equal to its share in the total trade.

A generalization of (9) would have e_i replaced by any equality index. For example when Atkinson's index [1970] is used, the equality index e_i would be defined as

$$e_i = \frac{[(1/2) \cdot (X_i^{(1-\varepsilon)} + M_i^{(1-\varepsilon)})]^{1/(1-\varepsilon)}}{(X_i + M_i)/2} \quad ,$$

the parameter ε measuring the importance one wishes to give to small values of imports and exports.

A new index of trade overlap which would be a combination of the GL- and Atkinson's index (GLA) may then be proposed and written as

$$\mathrm{GLA} = \sum_{i=1}^{n} t_i \cdot \frac{[(X_i^{1-\varepsilon} + M_i^{1-\varepsilon})/2]^{1/(1-\varepsilon)}}{(X_i + M_i)/2} \quad . \tag{10}$$

It will now be shown that the MA index may also be defined as an *equality* index. From (5) one derives that

$$\begin{aligned} \mathrm{MA} &= 1 - (1/2) \sum_{i=1}^{n} [(X_i/X) \cdot \mid 1 - ((M_i/X_i)/(M/X)) \mid] \\ &= 1 - \sum_{i=1}^{n} [(X_i/X)(\mid r - r_i \mid /2r)] \quad , \end{aligned} \tag{11}$$

where $r_i = (M_i/X_i)$ is the ratio of imports over exports in industry i; r is the ratio of imports over exports in the whole economy. Since $r = (M/X) = \sum_{i=1}^{n} (X_i/X) \cdot (M_i/X_i)$, equation (11) indicates that the MA index is the complement to one of half the weighted relative mean deviation of the ratios r_i.[8]

[8]It may be proven that 2 is the maximal value of a relative mean deviation, hence, the coefficient (1/2) in equation (11).

Since the relative mean deviation is only one among several possible indices of inequality, it appears that like the GL index, the MA index may be generalized. For example, if one wishes to use the Atkinson index of inequality, (11) would give what could be called the Michaely/ Aquino/Atkinson index (MAA), written as[9]

$$\text{MAA} = \frac{[\sum_{i=1}^{n}(X_i/X)\cdot(M_i/X_i)^{(1-\varepsilon)}]^{1/(1-\varepsilon)}}{(M/X)} \quad . \tag{12}$$

The MA index may therefore be considered as the complement to one of the index measuring the inequality of the ratios (M_i/X_i) in the various industries.

In the previous section it was shown that the basic difference between indices of the GL type and those of the MA type stemmed from the fact that a distance could be defined either as one between dollar values (trade flows) or one between shares (trade patterns). It has now been shown that another criterion of classification is related to the way in which equality is defined: equality of the (M_i/X_i) ratios or weighted average of the equality inherent in each couple $\{X_i, M_i\}$. Although it seem there are two reasons for making a basic distinction between intra-industry trade indices of the Grubel/Lloyd and the Michaely/Aquino types, the following section will show that one may often expect a strong positive correlation between these indices. An empirical illustration confirms this prediction.

4 On the Covariation of Intra-Industry Indices: Theoretical Considerations

Despite the fact that, as indicated in *section 3*, the Grubel/Lloyd and Michaely/Aquino indices seem to measure different kinds of equalities, it will

[9]It has been shown elsewhere (Silber [1989]), that Glejser's indices [1979] of intra-industry trade specialization may be also expressed as Atkinson-type indices.

be shown that in many important specific cases they will have similar values. Let us take as a first case that of complete specialization, the one in which the country does not import and export at the same time the same good i (i.e. if $M_i \neq 0$; $X_i = 0$ and if $M_i = 0$, $X_i \neq 0, \forall i$). It can be seen that in such a case both the MA and the GL indices will be equal to zero. The second specific case is that in which $M_i = X_i, \forall i$. Obviously, here both the MA and the GL will be equal to 1. A third example refers to the more general case where there is an overall balance of trade (i.e. $\sum_{i=1}^{n} M_i = \sum_{i=1}^{n} X_i$), but one may have $M_i \neq X_i, \forall i$. In such a case the GL and MA indices will be equal as will now be proven.

Using expression (1) it can be seen that the Grubel/Lloyd-index may also be written as

$$\mathrm{GL} = 1 - \sum_{i=1}^{n}(X_i/X)(\mid 1 - r_i \mid/(1+r)) \quad . \tag{13}$$

The comparison of (11) and (13) indicates that when $r = 1$, GL will be equal to MA.

A fourth interesting case is that in which $r = r_i \neq 1, \forall i$. The MA index will then be equal to one. The GL is equal to $\frac{2}{1+r}$ if $r > 1$ and to $\frac{2r}{1+r}$ if $1 > r$. However, the difference between the values taken by the GL and the MA indices stems from the fact that there is overall trade imbalance. Grubel/Lloyd suggested to use in such a case a *corrected* index GL^c which they defined as [10]

$$\mathrm{GL}^c = \frac{\sum_{i=1}^{n}(M_i + X_i) - \sum_{i=1}^{n} \mid M_i - X_i \mid}{\sum_{i=1}^{n}(M_i + X_i) - \mid \sum_{i=1}^{n} M_i - \sum_{i=1}^{n} X_i \mid}$$

$$= \frac{X + M - \sum_{i=1}^{n}[X_i + M_i - 2 \cdot min\{X_i, M_i\}]}{X + M - [X + M - 2 \cdot min\{X; M\}}] \quad .$$

[10] since $\mid a - b \mid = (a + b - 2 \cdot min\{a, b\})$.

After simplification the expression becomes

$$\mathrm{GL}^c = \frac{\sum_{i=1}^{n} min\{X_i, M_i\}}{min\{(X, M)\}} \quad . \tag{14}$$

However, if $r = r_i, \forall i$ it can be seen that if

$$\begin{aligned} r &> 1, \sum_{i=1}^{n} min\{X_i, M_i\} = \sum_{i=1}^{n} X_i = X = min\{X, M\} \\ r &< 1, \sum_{i=1}^{n} min\{X_i, M_i\} = \sum_{i=1}^{n} M_i = M = min\{X, M\} \quad . \end{aligned}$$

In both cases $GL^c = 1$, the value taken by the MA index, as was previously indicated.

There are, however, cases where the GL and MA indices may move in opposite directions. It has been previously shown that the MA index depends on the values taken by the ratios $\mid r - r_i \mid /r$, whereas the GL index depends on the values taken by the ratios $\mid 1 - r_i \mid /(1 + r)$. Let us assume that we observe a country at two different periods, that $r_k > r > 1 > r_h$ and that M_k increases by b dollars whereas M_h decreases by the same amount. In such a case there is no change in the weights (X_i/X) as well as in r. All four expressions $\mid r - r_k \mid, \mid r - r_h \mid, \mid 1 - r_k \mid, \mid 1 - r_h \mid$ will increase so that both the GL and MA indices will decrease. This would also be true if, for example, $r_k > 1 > r_h > r$, or if $r_k > 1 > r > r_h$. The indices GL and MA would move in opposite directions in cases like those where $r_k > r > r_h > 1$ or $r > r_k > 1 > r_h$. In short, there are, certainly, instances in which the two types of indices may move in opposite directions. However, when one compares two situations (a given country at two different times or two countries at the same time), one usually has to assume that most, if not all, the M_i's and X_i's varied, so that predictions concerning changes in the GL and MA indices are now difficult to make. The question at the limit becomes an empirical one.

5 On the Covariation of Intra-Industry Trade Indices: Empirical Results

In our analysis we have attempted to get an idea of the extent of the co-variation between the GL and MA indices by looking at the 1974 und 1984 imports and exports data (at the three digit level) of the following countries: Denmark, Federal Republic of Germany, France, Ireland, Israel, Italy, the United Kingdom, and the United States of America. Various intra-industry trade indices have been computed. The results are presented for each country and year in *Table 1* and *2*.

As a whole it appears that the ranking of the different countries is quite similar, whatever index in chosen, this being true for both types of indices, those measuring trade overlap (Table 1) and those looking at the similarity of trade patterns (Table 2). France, the United Kingdom and the Federal Republic of Germany have the highest level of intra-industry trade whereas Israel has quite a low level of intra-industry trade. Inbetween one finds the USA and Denmark with levels quite close to those of France, West Germany and the United Kingdom, and Ireland and Italy for which the level of intra-industry trade is quite higher than that of Israel but lower than that of the other countries.

These conclusions are true for both 1974 and 1984 but some trends may be observed. The level of intra-industry trade has increased during this period for the following countries: Ireland, Italy, the United Kingdom and the United States, whereas the results are more ambiguous for France, West Germany, Denmark and Israel, and vary according to the index chosen. Correlations coefficients between the various indices have therefore been computed in order to see whether the conclusions depend significantly on the type of index selected. *Table 3* gives the correlation matrix between the various indices.

There appears to be a strong positive correlation between most indices.

Naturally, the size of the sample is small: 16 oberservations (eight countries and two years) but most results are significant. One may note, in particular, that if one excludes the correlations between the same type of indices, the highest correlation observed is that between the traditional Grubel/Lloyd GL^1 and Michaely/Aquino MA^1 indices (the coefficient of correlation is equal to 0.989).

It seems, therefore, that there is not much point in making a strong distinction between indices measuring the amount of trade overlap and those measuring the similarity of import and export patterns. Additional empirical work based on a greater number of observations may however be needed to confirm such a strong conclusion.

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Table 1: Trade Overlap Indices for various countries

Country; Year	GL^1	GL^2	GL^c	GLA $\varepsilon = 0.10$	GLA $\varepsilon = 0.05$	GLA $\varepsilon = 0.99$
Denmark						
1974	.534	.882	.610	.980	.879	.759
1984	.514	.901	.527	.981	.892	.785
West Germany						
1974	.467	.849	.551	.978	.976	.752
1984	.589	.899	.615	.986	.923	.848
France						
1974	.648	.843	.707	.985	.909	.819
1984	.607	.859	.616	.983	.904	.809
Ireland						
1974	.417	.845	.475	.970	.809	.617
1984	.504	.873	.515	.979	.878	.756
Israel						
1974	.207	.755	.369	.950	.679	.354
1984	.256	.740	.302	.955	.722	.446
Italy						
1974	.379	.718	.383	.965	.783	.569
1984	.479	.859	.516	.975	.858	.718
United Kingdom						
1974	.599	.852	.724	.982	.896	.793
1984	.676	.909	.717	.991	.950	.901
United States						
1974	.428	.837	.439	.972	.838	.618
1984	.470	.861	.575	.976	.863	.727

GL^1 Grubel and Lloyd index of intra-industry trade

GL^2 Grubel and Lloyd index with $q = 2$ (cf Section 2)

GL^c Extended Grubel and Lloyd index (for the case of trade imbalance)

GLA New index of trade overlap (a combination of the Grubel and Lloyd index and the Atkinson index of inequality as indicated in Section 3)

Table 2: Similarity of Trade Pattern Indices for various countries

Country; Year	MA^1	MA^2	MAA $\varepsilon = 0.1$	MAA $\varepsilon = 0.05$	MAA $\varepsilon = 0.99$
Denmark					
1974	.538	.885	.928	.646	.000
1984	.515	.901	.919	.520	.000
West Germany					
1974	.505	.851	.915	.669	.489
1984	.596	.898	.949	.794	.666
France					
1974	.637	.850	.848	.680	.546
1984	.607	.860	.887	.652	.429
Ireland					
1974	.430	.839	.906	.504	.000
1984	.503	.874	.929	.671	.007
Israel					
1974	.270	.777	.856	.330	.000
1984	.256	.724	.835	.378	.000
Italy					
1974	.381	.719	.844	.452	.060
1984	.480	.865	.845	.521	.230
United Kingdom					
1974	.557	.863	.890	.664	.513
1984	.670	.902	.954	.815	.675
United States					
1974	.428	.835	.873	.503	.164
1984	.475	.869	.885	.563	.298

MA^1 Michaely-Aquino index of similarity of trade patterns

MA^1 Michaely-Aquino index with $q = 2$ (cf Section 2)

MAA New index of similarity of trade patterns (a combination of the Michaely-Aquino index and of the Atkinson index of inequality, as indicated in Section 3)

Table 3: Correlation Matrix Between Various Indices

	GL^1	GL^2	GL^c	GLA $\epsilon = 0.1$	GLA $\epsilon = 0.5$	GLA $\epsilon = 0.99$	MA^1	MA^2	MAA $\epsilon = 0.1$	MAA $\epsilon = 0.5$	MAA $\epsilon = 0.99$
GL^1		0.781	0.936	0.978	0.967	0.967	0.989	0.770	0.543	0.922	0.715
GL^2			0.748	0.860	0.861	0.860	0.806	0.989	0.777	0.824	0.445
GL^c				0.897	0.878	0.877	0.937	0.772	0.516	0.866	0.757
$GLA(\epsilon = 0.1)$					0.997	0.997	0.997	0.841	0.650	0.955	0.687
$GLA(\epsilon = 0.5)$						1.000	0.963	0.840	0.636	0.946	0.674
$GLA(\epsilon = 0.99)$							0.963	0.839	0.634	0.945	0.675
MA^1								0.801	0.590	0.939	0.734
MA^2									0.748	0.803	0.450
$MAA(\epsilon = 0.1)$										0.764	0.313
$MAA(\epsilon = 0.5)$											0.730

GL^1 Grubel and Lloyd index of intra-industry trade
GL^2 Grubel and Lloyd index with q = 2 (cf Section 2)
GL^c Extended Grubel and Lloyd index (for the case of trade imbalance)
GLA New index of trade overlap (a combination of the Grubel and Lloyd index and the Atkinson index of inequality as indicated in Section 3)
MA^1 Michaely-Aquino index of similarity of trade patterns
MA^1 Michaely-Aquino index with q = 2 (cf Section 2)
MAA New index of similarity of trade patterns (a combination of the Michaely-Aquino index and of the Atkinson index of inequality, as indicated in Section 3)