Intra- Vs. Inter-Industry Trade: The Case of Many Countries and Industries

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The shares of inter- and intra-industry trade are calculated by *Grubel/Lloyd* (1971, 1975) for the case of many product groups, but only a single country. In the case of many countries, country-specific import and export values have to be considered. To determine the trade shares in this case, *Ramhorst* (1978), *Nobel* (1981) and *Schmitt-Rink* (1983) have used the concept of triangulation of trade matrices. However, this analytical approach faces the problem to define which transactions are concerned to be inter- or intra-industry trade. In this paper, a generalization of Grubel/Lloyd's approach is offered as an alternative.

I. Introduction

An increasing amount of total world trade has become the exchange of differentiated products which are close substitutes or — in other words — has become the exchange of commodities used for the same purposes and therefore belonging to the same product group. This intra-industry trade has to be statistically separated from inter-industry trade, the exchange of different commodities belonging to different product groups. As is well known, *Grubel/Lloyd* (1971, 1975) restrict their analytical approach to the case of many product groups, but only a single country. Therefore, they do not distinguish between different import and export countries. But in the case of many countries the assessment of the relative importance of inter- and intra-industry transactions requires not the consideration of total, but of country-specific import and export values. To overcome this deficiency of Grubel/Lloyd's approach, *Ramhorst* (1978), *Nobel* (1981) and — with critical comments to the former — *Schmitt-Rink* (1983) have used the concept of triangulation of trade matrices. However, this analytical approach faces the problem to define which transactions are concerned to be inter- or intra-industry trade. Calling the absolute value of the difference between imports and exports net trade and the sum of imports and exports gross trade, inter-industry trade is defined as the share of net in gross trade, intra-industry as one minus this share.

In this paper it is argued, (1) that the amount of net trade is — compared with the general definition of inter- and intra-industry

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trade by *Grubel/Lloyd* — not correctly determined by *Ramhorst* (1978), *Nobel* (1981) and *Schmitt-Rink* (1983), (2) that the triangulation of trade matrices is not necessary to assess the relative importance of inter- and intra-industry trade in the case of many countries and (3) that a generalization of Grubel/Lloyd's approach to the case of many countries leads to a consistent concept of measurement.

In the following, chapter II presents an assessment of the different analytical approaches. The plausibility of the formulas is proved by an example of four countries exchanging three product groups. Finally, chapter III concludes the paper by suggesting some implications for empirical analyses.

II. Analytic Approaches

1. Grubel/Lloyd's Approach

The share of inter-industry trade q and intra-industry trade $1 - q$ in total trade of one product group i of a single country j is determined by Grubel/Lloyd[1] as

$$q_{ij} = |X_{ij} - M_{ij}| / (X_{ij} + M_{ij}) \tag{1}$$

and

$$1 - q_{ij} = \frac{(X_{ij} + M_{ij}) - |X_{ij} - M_{ij}|}{(X_{ij} + M_{ij})}, \tag{2}$$

respectively. X_{ij} (M_{ij}) indicates the exports (imports) of country j of product group i.

Calling the absolute value of the difference between imports and exports net trade and the sum of imports and exports gross trade, inter-industry trade is defined as the share of net in gross trade, intra-industry trade as one minus this share.[2]

In the case of many product groups i ($i = 1, 2, \ldots, n$), the share of inter-industry trade in total trade of a single country j (q_j) is determined as a weighted average of the country- and product-specific values q_{ij}. The shares of imports and exports of each product group i in total imports of country j (α_{ij})

$$\alpha_{ij} = (X_{ij} + M_{ij}) / \sum_i (X_{ij} + M_{ij}) \qquad i = 1, 2, \ldots, n \tag{3}$$

are average forming weights.

$$q_j = \sum_i \alpha_{ij}\, q_{ij} \qquad i = 1, 2, \ldots, n \tag{4}$$

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[1] *Grubel/Lloyd* (1975), 20 - 22.

[2] Because of the supplementary nature of the formulas, the ones for inter-industry trade are only stated in the following.

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(1) and (3) placed in (4) leads to

$$q_j = \sum_i | X_{ij} - M_{ij} | / \sum_i (X_{ij} + M_{ij}) \qquad i = 1, 2, \ldots, n \; . \tag{4a}$$

Although Grubel/Lloyd do not distinguish between different import and export countries, it is obvious that the product-specific imports and exports of one country are aggregates of their country-specific basics.

$$\begin{aligned} X_{ij} &= \sum_k X_{ijk} \\ M_{ij} &= \sum_k M_{ijk} \end{aligned} \qquad k = 1, 2, \ldots, j-1, j+1, \ldots, m \tag{5}$$

(k indicates all countries trading product group i with country j.)

Hence, the product-specific and global shares of inter-industry trade of a single country are transformed to

$$q_{ij} = | \sum_k X_{ijk} - \sum_k M_{ijk} | / (\sum_k X_{ijk} + \sum_k M_{ijk}) \qquad k = 1, 2, \ldots, j-1, j+1, \ldots, m \tag{1a}$$

and

$$q_j = \sum_i | \sum_k X_{ijk} - \sum_k M_{ijk} | / \sum_i (\sum_k X_{ijk} + \sum_k M_{ijk}) \; , \qquad \begin{aligned} i &= 1, 2, \ldots, n \\ k &= 1, 2, \ldots, j-1, j+1, \ldots, m \end{aligned} \tag{4b}$$

respectively.[3]

2. The Approach of Triangularized Trade Matrices

In the case of many countries and a single product group, the country-specific import and export values can be summarized in a product-specific matrix, whose rows include the exports a_{jk} of one country j to all other countries k and whose columns show the imports a_{kj} of one country j from all the other countries k. The triangulation of this trade matrix rearranges the position of each country until the sum of exports to the subsequently arranged countries becomes a maximum for all countries, i. e. until the sum of elements above the main diagonal becomes a maximum and the one of the elements below the main diagonal a minimum. The ratio of all elements above the main diagonal to all elements of the matrix reflects the degree of reaching a diagonal

[3] On the lowest possible aggregation level, even

$$q_{ijk} = | X_{ijk} - M_{ijk} | / (X_{ijk} + M_{ijk})$$

may be defined. But this share of inter-industry trade in two countries' trade of one product group seems to be meaningless for structural analyses of total world trade.

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matrix. *Ramhorst* (1978) and *Nobel* (1981) identify this ratio as the share of inter-industry trade in total trade.[4]

$$q_i = \sum_j \sum_k a^*_{jk} / \sum_j \sum_k a_{jk} \tag{6}$$

(a^*_{jk} indicates the elements above the main diagonal.)

Defining inter-industry trade as the share of net in gross trade, the sum of all trade values above the main diagonal of the triangularized matrix should coincide with the volume of inter-industry trade. However, as *Schmitt-Rink* (1983) pointed out, in the case of positive trade values below the main diagonal, the volume of inter-industry trade is smaller than the sum of all trade values above the main diagonal. Since net trade is defined as the absolute value of the difference between imports and exports, in this case the volume of inter-industry transactions is equal to the sum of the absolute values of the differences between the elements a^*_{jk} above the main diagonal and the corresponding a^*_{kj} below the main diagonal. Therefore, *Schmitt-Rink* (1983) calculates the share of inter-industry trade according to the formula

$$q_i = \sum_j \sum_k | a^*_{jk} - a^*_{kj} | / \sum_j \sum_k a_{jk} \,. \tag{7}$$

However, Schmitt-Rink's correction is necessary, but not sufficient. If country B imports a certain product group from country A and exports the same product group to country C, the trade of this product group is partly intra-industry trade according to the definition of inter- and intra-industry trade by Grubel/Lloyd. But the analytical approach of triangularized trade matrices — whether corrected or not — leads to the classification of this trade as exclusively inter-industry trade.[5] The import and export streams between the countries A, B and C are all arranged above the main diagonal. Therefore, the correcting of the elements above the main diagonal by the corresponding ones below the main diagonal is not sufficient to determine the volume of inter-industry transactions. Generally, expression (7) as well as expression (6) lead to an over-estimation of the share of inter-industry trade. Hence, a generalization of Grubel/Lloyd's approach to the case of many countries is developed as an alternative.

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[4] In the literature, this ratio is called the empirical degree of linearity. See *Helmstädter* (1957) and *Korte/Oberhofer* (1968 a), (1970).

[5] See product 1 of the example in chapter II.3.

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3. A Generalization of Grubel/Lloyd's Approach

Following the lines of *Grubel/Lloyd* (1971), (1975), in the case of many countries j ($j = 1, 2, \ldots, m$) and a single product group i the volume of inter-industry trade is determined in the same way as in the case of many product groups i ($i = 1, 2, \ldots, n$) and a single country j. Since net trade, i. e. the volume of inter-industry trade, is identified as the absolute value of the difference between imports and exports, Grubel/Lloyd's approach is generalized to the case of many countries by aggregating their country- and product-specific inter-industry trade index q_{ij}

$$q_{ij} = \left| \sum_k X_{ijk} - \sum_k M_{ijk} \right| / \left(\sum_k X_{ijk} + \sum_k M_{ijk} \right) \tag{1a}$$
$$k = 1, 2, \ldots, j-1, j+1, \ldots, m$$

according to the number of countries j. In the case of many countries, the share of inter-industry trade in total trade of a product group i (q_i) is determined as a weighted average of the country- and product-specific values q_{ij}. The shares of imports and exports of each country j ($j = 1, 2, \ldots, m$) in total imports and exports of product group i (β_{ij})

$$\beta_{ij} = \left(\sum_k X_{ijk} + \sum_k M_{ijk} \right) / \sum_j \left(\sum_k X_{ijk} + \sum_k M_{ijk} \right) \tag{8}$$
$$j = 1, 2, \ldots, m$$
$$k = 1, 2, \ldots, j-1, j+1, \ldots, m$$

are the average forming weights.

$$q_i = \sum_j \beta_{ij} q_{ij} \qquad j = 1, 2, \ldots, m \tag{9}$$

(1a) and (8) placed in (9) leads to

$$q_i = \sum_j \left| \sum_k X_{ijk} - \sum_k M_{ijk} \right| / \sum_j \left(\sum_k X_{ijk} + \sum_k M_{ijk} \right) \tag{9a}$$
$$j = 1, 2, \ldots, m$$
$$k = 1, 2, \ldots, j-1, j+1, \ldots, m \; .$$

The inter-industry trade index (9a) is correctly specified: The summation of the absolute values of the differences between country-specific imports and exports across countries determines the volume of interindustry transactions.[6]

To illustrate the different outcome resulting from the formulas (6), (7) and (9a), a theoretical example of four countries A, B, C and D

[6] Summing up country-specific trade values across countries in the numerator of (9a) implies a twofold consideration of each import and export value. Hence, it is not surprising, that the denominator of (9a) is equal to the double sum of all trade values.

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exchanging three product groups 1, 2 and 3 is used. The import and export streams are summarized in the following product-specific trade matrices, which are all triangularized.

Product Group 1	A	B	C	D
A	0	100	100	100
B	0	0	90	90
C	0	0	0	80
D	0	0	0	0

Product Group 2	A	B	C	D
A	0	100	100	100
B	10	0	90	90
C	0	0	0	80
D	0	0	0	0

Product Group 3	A	B	C	D
A	0	100	100	100
B	100	0	90	90
C	100	90	0	80
D	100	90	80	0

According to the different analytical approaches, the share of inter-industry trade in each product group's trade depends on the selection of formula (6), (7) or (9a).

	Formula (6)	(7)	(9a)
q_1	1,0	1,0	0,679
q_2	0,982	0,965	0,667
q_3	0,5	0,0	0,0

Obviously, the generalized Grubel/Lloyd-approach (9a) avoids the over-estimation of the volume of inter-industry trade according to expressions (6) or (7).

Besides the correct specification of the volume of inter-industry transactions in the case of many countries, the generalized Grubel/Lloyd-approach needs no triangulation procedure to determine the volume of inter- and intra-industry trade. The triangulation of trade matrices is not necessary to assess the relative importance of inter- and intra-industry trade in the case of many countries.

So far, the shares of inter-industry trade are determined (1) across product groups (see (4b)) and (2) across countries (see (9a)). In the case of many product groups i ($i = 1, 2, \ldots, n$) and many countries j ($j =$

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1, 2, ..., m) the total share of inter-industry trade in total trade of all product groups and countries (q) can be derived in two different, but coinciding ways. On the one hand, following a country approach, the total share of inter-industry trade is determined as a weighted average of the country-specific values q_j. The shares of total imports and exports of each country j ($j = 1, 2, \ldots, m$) in total imports and exports (α_j)

$$\alpha_j = \sum_i \left(\sum_k X_{ijk} + \sum_k M_{ijk}\right) \Big/ \sum_j \sum_i \left(\sum_k X_{ijk} + \sum_k M_{ijk}\right) \tag{10}$$

$$i = 1, 2, \ldots, n$$
$$j = 1, 2, \ldots, m$$
$$k = 1, 2, \ldots, j-1, j+1, \ldots, m$$

are the average forming weights.

$$q = \sum_j \alpha_j q_j \qquad j = 1, 2, \ldots, m \tag{11a}$$

On the other hand, following a commodity approach, the total share of inter-industry trade is determined as a weighted average of the product-specific values q_i. The shares of total imports and exports of each product group i ($i = 1, 2, \ldots, n$) in total imports and exports (β_i)

$$\beta_i = \sum_j \left(\sum_k X_{ijk} + \sum_k M_{ijk}\right) \Big/ \sum_i \sum_j \left(\sum_k X_{ijk} + \sum_k M_{ijk}\right) \tag{12}$$

$$i = 1, 2, \ldots, n$$
$$j = 1, 2, \ldots, m$$
$$k = 1, 2, \ldots, j-1, j+1 \ldots, m$$

are the average forming weights.

$$q = \sum_i \beta_i q_i \qquad i = 1, 2, \ldots, n \tag{11b}$$

(4b) and (10) placed in (11a) as well as (9a) and (12) placed in (11b) lead to

$$q = \sum_i \sum_j \left| \sum_k X_{ijk} - \sum_k M_{ijk} \right| \Big/ \sum_i \sum_j \left(\sum_k X_{ijk} + \sum_k M_{ijk}\right) \tag{11c}$$

$$i = 1, 2, \ldots, n$$
$$j = 1, 2, \ldots, m$$
$$k = 1, 2, \ldots, j-1, j+1, \ldots, m\ .$$

Generally, inter-industry trade is defined as the share of net in gross trade, i. e. as the share of the sum of the absolute values of the differences between imports and exports in the sum of all imports and exports. The inter-industry trade indices of the generalized Grubel/ Lloyd-approach are consistent with this general rule on all aggregation

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levels. q_{ij} (1a), q_j (4b), q_i (9a) and q (11c) are all based on the same procedure. Therefore, both approaches to q lead to the same outcome.

III. Conclusions

The theoretical outcome of this contribution to the measurement of inter- and intra-industry trade in the case of many countries and product groups (industries) suggests the following conclusions:

(1) The analytical approach of triangularized trade matrices is rejected because of over- (under-) estimated volumes of inter- (intra-) industry trade.

(2) The triangulation of trade matrices is not necessary to assess the relative importance of inter- and intra-industry trade in the case of many countries.

(3) A generalization of Grubel/Lloyd's approach following the general definition of inter- and intra-industry trade provides consistent measures on all possible aggregation levels.

Empirical analyses of the inter- and intra-industry structure of total world trade or of total trade of groups of countries can be based upon the measures resulting from the generalized Grubel/Lloyd-approach. Besides country- and product-specific shares of inter- (q_{ij}) and intra- ($1 - q_{ij}$) industry trade, the structural composition of total world trade is alternatively derivable from a country approach (q_j) or a commodity approach (q_i). Both approaches are consistent and, therefore, lead to the same total share of inter- and intra-industry trade in total trade of all product groups and countries (q and $1 - q$, respectively).

Summary

This contribution to the measurement of inter- and intra-industry trade in the case of many countries and product groups points out (1) that the analytical approach of triangularized trade matrices is rejected because of over- (under-) estimated volumes of inter- (intra-) industry trade, (2) that the triangulation of trade matrices is not necessary to assess the relative importance of inter- and intra-industry trade in the case of many countries and (3) that a generalization of Grubel/Lloyd's approach following the general definition of inter- and intra-industry provides consistent measures on all possible aggregation levels.

Zusammenfassung

In diesem Beitrag zu den Meßkonzepten des inter- und intra-industriellen Handels im Fall mehrerer Länder und Produktgruppen wird argumentiert, (1) daß der analytische Ansatz triangulierter Handelsmatrizen den Anteil des

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inter- (intra-) industriellen Handels über- (unter-) schätzt, (2) daß die Triangulation von Handelsmatrizen zur Bestimmung der relativen Bedeutung des inter- und intra-industriellen Handels im Fall mehrerer Länder nicht erforderlich ist und (3) daß eine Verallgemeinerung des Ansatzes von Grubel/Lloyd auf der Basis der allgemeinen Definition des inter- und intra-industriellen Handels zu einem auf allen Aggregationsebenen konsistenten Meßkonzept führt.

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