

On the Theoretical Interpretation of Indices of Trade Intensity and Revealed Comparative Advantage

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I. Introduction

Researchers have employed a number of measures of trade performance to study the structure and determinants of a country's foreign trade¹. A commonly used family of measures are indices of trade intensity, the most popular member of this family being the index of revealed comparative advantage². The form of each index and the interpretation given to their values has varied from author to author, but the empirical and theoretical literature appear to agree that a country reveals a comparative advantage (disadvantage) in a commodity if an index's value is greater (less) than one.

Kunimoto [1977] recently attempted to provide a theoretical basis for interpreting deviations in these indices from unity as indicating comparative advantage. Working in a probabilistic framework, he argued that such deviations measure the extent to which actual trade deviates from the trade expected in a world in which factors influencing the direction (but not the level) of a country's trade are absent. Alternatively, Yamazawa [1970] specified that deviations from unity indicate deviations in actual trade from the trade predicted by a gravity model. Indirect evidence that deviations from unity are interpreted as indicating relative

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¹ See Aho *et al.* [1980] for a comparison of commonly used measures when applied to an analysis of U.S. trade performance.

² This index is most often associated with the work of Balassa [e.g., Balassa, 1967]. Other works employing such measures include Brown [1948], Yamazawa [1970; 1971], Kojima [1970; 1971], and Roemer [1977]. — The term "comparative advantage" is perhaps misapplied in this literature since only exports are typically considered whereas comparative advantage is properly a net trade concept. Comparative advantage is used here for consistency with the literature but the reader may wish to consider substituting "comparative export advantage". In any event, such considerations in no way affect the results presented here.

advantage is provided by authors such as Roemer [1977], who compute the cross-commodity variation in such indices for a particular country around unity and not the mean of the index.

This paper examines the theoretical basis for this common interpretation and demonstrates that it rests upon the implicit assumption that a country exports every commodity. Such an assumption is, in general, inappropriate in a trading environment and it is shown that under economically reasonable assumptions values of a trade intensity index above (below) unity cannot be used to infer a country's relative advantage (disadvantage) in any given commodity. In response to this failure of the theoretical framework, this paper presents two alternative indices for revealing comparative advantage derived from a model of trade.

The paper is organized as follows. Section II reviews the current theory of trade intensity indices and presents the problem associated with this theory. Section III presents the alternative indices for revealing comparative advantage. Section IV contains concluding remarks.

II. Current Theory

Consider the index of revealed comparative advantage (I_{ik}) given as¹

$$I_{ik} = (X_{ik}/X_i)/(X_k/X) \quad (1)$$

where X_{ik} = country i 's exports of commodity k , X_i = country i 's total exports, X_k = total world exports of commodity k , and X = total world exports. Following Kunimoto [1977], I_{ik} can be interpreted as the ratio of actual exports of commodity k by country i to the exports of commodity k by country i expected in a world in which world exports of commodity k are distributed among countries in proportion to their share of world exports. Denoting this expected trade by $E(X_{ik})$, then

$$E(X_{ik}) = (X_i/X) \cdot X_k \quad (2)$$

and thus from (1)

$$I_{ik} = X_{ik}/E(X_{ik}) \quad (3)$$

Kunimoto argued that deviations in I_{ik} from unity indicate the presence of factors which influence the distribution of a country's trade among countries without affecting the level of its trade. That is, he hypothesized

¹ As Kunimoto [1977] shows, all of the indices are interrelated and it can be shown that the following discussion applies to each.

a world in which those factors determining the level of a country's trade can be separated from those factors determining the geographic distribution of its trade. Expected trade, $E(X_{ik})$, then represents the trade that would be observed in the hypothetical ("neutral") world where these latter factors are absent.

Given this, Kunimoto showed that the various indices employed in the literature were all derivable as alternative hypotheses of statistical independence in a contingency table analysis of trade. This alternative probability foundation for (3) is derived by considering X_{ik} to represent a frequency of transactions in commodity k between residents of country i and residents of the rest of the world¹. If so, then the (joint) probability that commodity k is exported by country i is

$$X_{ik}/X \quad (4)$$

Similarly, define the (marginal) probabilities

$$X_k/X \quad \text{and} \quad (4a)$$

$$X_i/X \quad (4b)$$

Expression (4a) is the probability that commodity k is exported whereas (4b) is the probability that country i exports. If the assignment (classification) of countries and of commodities is independent, then (4) is given by

$$X_{ik}/X = (X_i/X) \cdot (X_k/X) \quad (5)$$

Multiplying both sides of (5) by X gives expected trade:

$$E(X_{ik}) = (X_i/X) \cdot X_k \quad (6)$$

The ratio of actual to expected trade then measures the extent to which a country and commodity interact. Again, the economic interpretation of this interaction is that $E(X_{ik})$ is the trade expected if factors that skew the geographic distribution of a country's trade are absent².

Whereas the above formulations of $E(X_{ik})$ have intuitive appeal, it is established below that in a world in which trade is determined by either

¹ This probability framework is essentially that presented by Leamer and Stern [1970].

² These factors should logically be thought to determine comparative advantage and not just trade distribution. Although Kunimoto sought to separate factors determining trade levels from factors determining geographic distribution, such a separation is clearly invalid since factors such as relative distance, political affiliations, etc., as well as traditional cost factors, all determine relative costs which simultaneously determine both the level and direction of trade.

(2) or (6), each commodity is either exported by all countries or exported by no country. This is, it is established that for $E(X_{ik})$ to be strictly positive for some country i and commodity k , it must be assumed that every country exports commodity k . Otherwise, if $E(X_{ik})$ is zero for some country i and commodity k , then $E(X_{jk})$ is zero for all countries j .

To assume that a country exports every commodity is not economically sensible. By definition of trade, if a country exports it also imports. Further, under standard assumptions, a country does not both export and import the same commodity. But this, together with the above, implies that expected trade is zero for every commodity, i. e., there is no trade in the hypothetical world in which trade flows are determined by (6). This follows directly since each commodity which is potentially tradeable must be imported by at least one country. Thus, for each commodity k there is at least one country i for which $E(X_{ik})$ is zero. But by the second result, $E(X_{jk})$ is then zero for each country j and commodity k . Thus, assuming a country does not export those commodities which it imports, and since trade means every commodity exported must also be imported, the preceding theoretical framework leads to the result that expected trade is actually zero for every commodity¹. Consequently, equation (3) is undefined and interpretation of deviations from unity is invalid. These propositions are now established formally.

Assume we are in the hypothetical world in which actual trade is determined by (6) so that $X_{ik} = E(X_{ik})$. To establish that if a commodity is exported by one country it is exported by all countries, assume that for some country i and some commodity k that $X_{ik} > 0$. It follows from (6) that $X_i > 0$ and $X_k > 0$. Thus, if country j exports at all (i. e., $X_j > 0$), then $X_{jk} > 0$ for all j (i. e., all countries export commodity k).

To establish that if a commodity is not exported by one country then no country exports that commodity, assume that for some country i and some commodity k that $X_{ik} = 0$. From (6) it follows that either $X_i = 0$, $X_k = 0$ or both. Now, if country i exports at all (i. e., $X_i > 0$) then $X_{ik} = 0$ for some k if and only if $X_k = 0$. Since $X_k = \sum_j X_{jk}$, then $X_{jk} = 0$ for all countries (i. e., no country exports commodity k).

Now, ruling out simultaneous export and import, if country i imports commodity k then $X_{ik} = 0$. Given this, the second result can be restated as saying that if commodity k is imported by some country then $X_k = 0$. Since, by definition of trade, each commodity must be imported by at

¹ It follows that the indices converge to zero in a world with no relative advantages contrary to Yamazawa's [1970] contention of a convergence toward unity.

least one country, it follows that $X_k = 0$ for each commodity k , i. e., there is no trade in the hypothetical world.

Since equation (3) would be defined if every country could be assumed to export every commodity, one could argue that by dealing only with aggregate groupings of commodities, or alternatively, by postulating intra-industry trade in every commodity, such an assumption could be maintained. It is unlikely one would argue strongly that intra-industry trade exists for each commodity no matter how fine the level of disaggregation. The appropriateness of using aggregation to justify use of equation (3) hinges on whether one should expect such "macro" indices to be derivable from underlying "micro" trade flows. If so, then the above argument remains valid¹.

One might conjecture that what Kunimoto actually had in mind in thinking of a neutral world was the pre-trade structure of a country's *production*. In this case the above difficulty could be overcome as each country could be assumed to produce, as opposed to export, each commodity. Under this interpretation, expected flows correspond to expected production flows in a world in which all countries are identical except for size. Deviations in a country's actual production from its expected production would then indicate specialization and, given identical tastes, would also indicate comparative advantage. It is shown below that such a "production intensity" index follows from a general model of trade.

III. Alternative Indices for Revealing Comparative Advantage

This section presents two indices for revealing comparative advantage derived from a model of trade. Theoretically, a fundamental difficulty with the preceding indices is that they treat exports and imports separately when comparative advantage is properly a net trade concept. Consequently, the indices presented here are based on net trade.

Begin with the following identity for net trade:

$$T_{ik} = Q_{ik} - C_{ik} \quad (7)$$

where: T_{ik} = net trade of country i in commodity k , Q_{ik} = country i 's production of commodity k , and C_{ik} = country i 's consumption of commodity k . Assuming countries to have identical homothetic preferences, each country's consumption of commodity k is proportional to the

¹ Restricting attention to subsets of commodities for which every country has a non-zero export does not invalidate the preceding argument since all that is needed for the indices to be undefined is that for some country i and some commodity k , $X_{ik} = 0$.

world's consumption (production) of commodity k . Therefore, letting Q_k be world production of commodity k , we can write

$$C_{ik} = s_i Q_k, \quad k = 1, \dots, K; \quad i = 1, \dots, N \quad (8)$$

It can be shown [Bowen, 1980, Appendix A] that the factor of proportionality, s_i , is the ratio of country i 's GNP (Y_i) to world GNP (Y). Given this, substitute first for s_i in (8) and then for C_{ik} in (7) to obtain

$$T_{ik} = Q_{ik} - \frac{Y_i}{Y} Q_k \quad (9)$$

which can be written

$$I_{ik}^T = (I_{ik}^Q - 1) \quad (10)$$

where $I_{ik}^T = \frac{T_{ik}}{(Y_i/Y) Q_k}$ and $I_{ik}^Q = \frac{Q_{ik}}{(Y_i/Y) Q_k}$

Equation (10) defines two indices from revealing comparative advantages among countries¹. Clearly, these indices are not independent. The "net trade intensity" index, I_{ik}^T , takes both positive and negative values and is zero when there is no comparative advantage or disadvantage. The "production intensity" index, I_{ik}^Q , takes only positive values and equals one when there is no comparative advantage or disadvantage. Since values of the production intensity index above (below) unity indicate comparative advantage (disadvantage), it is related in spirit to the preceding trade intensity indices. Note that the indices defined by (10) are based on actual trade whereas the indices discussed in Section II propose to compare actual trade with trade expected in a world of no relative advantages. A similar interpretation, however, can be given for the above indices.

Assume we are in a world of no relative advantages so that countries not only have identical homothetic tastes but are also identical with respect to relative factor supplies, technology, etc., but could differ in the absolute amount of resources. Each country's production vector coincides with its consumption vector so that $C_{ik} = Q_{ik}$ and, again, each country's consumption of commodity k will be proportional to the world's consumption (production) of commodity k . Consequently, (8) can be rewritten (after substituting for s_i) as

$$E(Q_{ik}) = (Y_i/Y) \cdot Q_k \quad (11)$$

¹ This form of the equation for net trade, whereby net trade is scaled by consumption, is directly linked to the proper computation of factor contents when testing the Heckscher-Ohlin theory [see Leamer, 1980].

where $E(Q_{ik})$ is properly interpreted as the production expected in this hypothetical world¹. Equation (11) has the same form as (2)² and thus, as in (3), the production intensity index can be written as

$$I_{ik}^Q = Q_{ik} / E(Q_{ik}) \quad (12)$$

Deviations in I_{ik}^Q from unity would be interpreted as indicating deviations in a country's actual production from the production expected in a world of no relative advantages.

Note that, consistent with the discussion in Section II, expected trade in this hypothetical world is zero since

$$E(T_{ik}) = E(Q_{ik}) - E(C_{ik}) = s_i (Q_k - Q_k) = 0$$

given the pre-trade proportionality of both a country's production and consumption with respect to the world. This makes clear that computation of trade intensity indices based entirely on trade flows is invalid under the interpretation that they measure deviations of actual trade from that expected in a "neutral" world of no relative advantages. The above indicates that the proper form of a revealed comparative advantage index based on trade flows would be

$$I_{ik}^T = T_{ik} / E(Q_{ik}) \quad (13)$$

where $E(Q_{ik})$ is computed according to (11). Even if one wanted to deal only with "exports" (commodities with positive net trade), it is expected production (or consumption) and not expected trade that should be used to scale actual trade. In terms of revealing comparative advantages among countries, the advantage of using I_{ik}^T instead of only net trade is that scale effects due to both commodity and country size are removed.

IV. Concluding Remarks

This paper has shown that imposing the assumption that a country does not export every commodity invalidates the theoretical basis for the common interpretation that values of trade intensity and revealed comparative advantage indices above (below) unity indicate relative advantage (disadvantage). In response, two indices for revealing comparative advantage based on net trade were derived. This analysis indicated that to interpret values of a trade intensity index as measuring

¹ It must be assumed each commodity is produced by every country if the $E(Q_{ik})$ are to be strictly positive.

² Note that one could derive (11) in a probability framework analogous to equations (4)–(6) using a matrix of production flows.

deviations in actual trade from trade expected in a neutral world of no relative advantages, the proper computation is the ratio of net trade to expected production.

The conclusions of this paper are similar to those of Hillman [1980] who examined whether cross-industry rankings of I_{ik} for a particular commodity reflect comparative advantage as given by pre-trade prices. He found that for cross-commodity comparisons I_{ik} was independent of a country's comparative advantage but for cross-country comparisons I_{ik} may reflect pre-trade prices under certain (restrictive) conditions. It should be noted that his analysis considered only relative rankings of the index and not values above or below unity.

Lastly, the analysis presented here does not deny the usefulness of trade intensity indices as summary measures of trade flows which eliminate certain scale effects. But the analysis of this paper indicates that it is in general inappropriate to interpret deviations from unity in such indices (as presently computed) as indicating comparative advantage.

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Zusammenfassung: Über die theoretische Interpretation der Indizes der Handelsintensität und der internationalen Wettbewerbsfähigkeit (RCA-Werte). — Die Annahme, ein Land exportiere nicht jedes Gut, entzieht der üblichen Schlußfolgerung, daß die über (unter) Eins liegenden Werte für die Handelsintensität und die internationale Wettbewerbsfähigkeit einen relativen Vorteil (Nachteil) anzeigen, die theoretische Basis. Daraufhin werden auf der Grundlage des Nettohandels zwei RCA-Indizes abgeleitet. Die Untersuchung verdeutlicht, daß man die Werte eines Index der Handelsintensität nur dann als Maß für die Abweichung des tatsächlichen Handels von dem Handel, der in einer neutralen Welt ohne relative Vorteile zu erwarten wäre, interpretieren kann, wenn man das Verhältnis zwischen Nettohandel und erwarteter Produktion verwendet.

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Résumé: Sur l'interprétation théorique des indices de l'intensité du commerce extérieur et d'avantage comparatif révélé. — Cet article démontre que la supposition qu'un pays n'exporte pas chaque bien invalide la base théorique pour l'interprétation commune de la proposition que les valeurs des indices de l'intensité du commerce extérieur et d'avantage comparatif révélé indiquent un avantage (désavantage) relatif si elles excèdent unité (sont < 1). En conséquence, l'auteur dérive deux indices pour révéler l'avantage comparatif basés sur le commerce extérieur net. Cette analyse indique que le calcul adéquat est la relation entre le commerce net et la production attendue si l'on veut interpréter les valeurs d'un indice de l'intensité du commerce extérieur comme mesure de la divergence entre le commerce actuel et le commerce attendu dans un monde neutre sans des avantages relatifs.

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Resumen: Sobre la interpretación de índices de intensidad comercial y ventajas comparativas reveladas. — Este artículo muestra que al imponerse el supuesto que un país no exporta todos los productos se invalida la base teórica para la interpretación común que los valores de intensidad comercial y los índices de ventajas comparativas reveladas superiores (menores) a la unidad indican una ventaja (desventaja) comparativa. En respuesta se derivaron dos índices para revelar ventajas comparativas basados sobre el comercio neto. Este análisis indica que para interpretar valores de un índice de intensidad comercial midiendo desviaciones comerciales reales de aquéllas esperadas en un mundo neutral sin ventajas relativas, la computación adecuada es la relación del comercio neto con respecto a la producción esperada.