TRADE INTENSITIES AND THE ANALYSIS OF BILATERAL TRADE FLOWS IN A MANY-COUNTRY WORLD: A SURVEY

By PETER DRYSDALE* AND ROSS GARNAUT**

I. *Introduction*

There is now scattered through the journals a considerable literature on the analysis and measurement of the various determinants of bilateral trade levels. The literature has identified a number of barriers (or *resistances*) to trade that, together with the various factors analysed in the pure theory of international trade, determine the size, commodity composition and welfare effects of bilateral trade flows.

The literature on the analysis of bilateral trade flows has proceeded along a number of independent paths, with some major contributions having been developed apparently in ignorance of other, closely related publications. This suggests the need for an integrating survey. This survey of the literature on the determinants of bilateral trade levels discusses the various methods that have been applied to the analysis of *resistances* to bilateral trade flows, and assesses evidence on the importance of these *resistances* in the determination of trade flows in a many-country world.

The concept of obstacles or *resistances* to bilateral trade flows is central to the *Survey*. We can define *resistances* to bilateral trade as any factors which prevent or retard the immediate international movement of commodities in response to price differentials. Recent theory distinguishes two basic types of *resistance: objective* resistances, which an individual firm can overcome only at some cost; and *subjective* resistances, which derive from the imperfect information available to businessmen, from internal constraints on profit-maximising behaviour and from the particular processes through which firms engaged in international trade take decisions that affect the volume or commodity composition of trade. *Objective* resistances can be further decomposed into *transport* and other costs of overcoming geographic distance, and the costs of overcoming *official barriers* to trade (for example, protection).[1]

The presence of *resistances* to bilateral trade causes absolute prices for given commodities (converted at some appropriate exchange rates) and also relative prices of commodities to vary from country to country.[2] The cost of overcoming *resistances* vary across bilateral

* Professor of the Australian National University.
** Senior Research fellow of the Australian National University.

[1] See R. G. Garnaut [25, 1972, pp. 25–26 and Chap. 6 *passim*] and R. G. Garnaut [24, 1980, Chap. 13]. Johnson suggested a slightly different categorisation, distinguishing 'geographic distance and the transport cost of overcoming it,' 'differences of political and legal systems, culture and language that differentiate nations from one another as market areas,' and 'protection'. H. G. Johnson [33, 1968].

[2] There are also *resistances* to inter-regional trade, and in some weakly integrated economies they have

trading relationships. As a result, the prices at which commodities are offered for international sale or purchase varies with the bilateral trading relationship within which the transaction is to be made. The reality that the price a country receives for its exports varies with the market to which it is sold, and that the price of imports varies with the market in which it is purchased, has profound implications for determination of the volume and commodity composition of foreign trade and for assessment of the gains from trade.

Mainstream trade theory has been developed to analyse the effects of one important type of *resistance* on bilateral trade levels: tariffs, quotas and other obstacles imposed by governments on trade. The *theory of protection* examines systematically the effects of obstacles imposed by one or both governments in a two-country world upon the volume, commodity composition and welfare effects of trade.[3] The *theory of customs unions* explores the effects of official constraints on trade being more costly to overcome in some bilateral trading relationships than in others.[4]

The pure theory of international trade has developed with little reference to trade *resistances* beyond *official barriers* to trade. But many authors have been impressed by casual empirical evidence on the importance of several other types of *resistances* to bilateral trade levels in determining the volume and composition of countries' foreign trade. The two-country models, so important in the pure theory of international trade, assume away all interesting questions about the determination of bilateral trade levels.[5] Evidence that an economy's aggregate export performance is correlated with the rate of growth of total imports into the particular foreign economies with which it has close ties cannot be understood in terms of the two-country model.[6] Equally challenging to established theory was evidence that, for some pairs of countries, resource endowments relative to each other provided a better guide to the commodity composition of bilateral trade than each country's resource endowment relative to the world as a whole.[7]

In response to the accumulation of evidence on the importance of bilateral trading relations in the determination of the volume and commodity composition of total foreign trade, Bhagwati in his important survey stated that established trade theory provides on *a priori* grounds for deciding whether bilateral trade is of no importance, of some importance or all-important.[8]

There have been a few attempts to integrate the concept of trade resistances into the general corpus of trade theory, most notably by Johnson.[9] Much more must be done before there is a satisfactory general trade theory that incorporates the reality of differential

caused wide regional price disparities. See H. W. Arndt and R. M. Sundrum, [3, 1975]. Border trade may occur between adjacent regions of two countries because the cost of overcoming intra-national resistances exceeds the cost of overcoming resistances to international trade. But the normal case is for resistances to international trade to be very much more important.

[3] See W. M. Corden, [11, 1971] and W. M. Corden, [12, 1974] for thorough treatments of the theory.

[4] There is a large literature on the theory of customs unions. For useful surveys, see R. G. Lipsey, [44, 1960] and J. Vanek [60, 1965].

[5] R. W. Jones, [34, 1977] reviews the limited discussion of many-country trade specialisation, in a world of zero transaction costs.

[6] Some of the literature on this point is discussed in E. L. Leamer and R. M. Stern, [42, 1970, Chap. 7].

[7] See, for example, M. Tatemoto and S. Ichimura, [54, 1959] which was the first in a series of Leontief-type studies to draw attention to this phenomenon.

[8] J. Bhagwati, [6, 1964, p. 20].

[9] H. G. Johnson, [33, 1968], and R. G. Garnaut [24, 1980].

costs of overcoming *resistances* in different bilateral trading relationships, a theory which can explain simultaneously bilateral trade flows and countries' total foreign trade. This *survey* has the more limited objective, outlined above, of laying out the literature on the nature, determinants, measurement and use of the *resistances* concept.

Much of the statistical analysis of trade flows in a many-country world that has been undertaken over the years has been applied to the attempt to understand the nature of *resistances* to bilateral trade flows and their importance in the determination of trade patterns. Some has been applied further to the projection of bilateral trade flows into the future, on the assumption that there is some predictability over time in patterns of resistances as measured by various statistical indexes.

Two approaches can be identified amongst systematic studies of the determinants of bilateral trade levels. The *gravity model* approach seeks to explain each bilateral trade flow independently, by reference to measures of the 'trade potential' of the two economies and to resistances to bilateral trade. The assumption of independent bilateral trade flows gives rise to attempts at estimation of countries' total imports and exports as the sum of these bilateral trade flows. The *intensity* approach, on the other hand, does not seek to explain countries' total imports and exports. It takes total imports and exports as given and measures and seeks to explain deviations from bilateral trade flows that would obtain if resistances to trade were equal on all bilateral routes. In some applications of the *intensity* approach, the measures of deviations from randomly established patterns of trade are assumed to be more or less stable over time and are used to project bilateral trade flows on given assumptions about the growth of individual countries' and total world trade.

The next two sections of the paper survey the major contributions that have been made to the analysis of trade *resistances* and the determination of bilateral trade flows within the *gravity model* approach and the *intensity* approach. A third section discusses the use in trade projections of concepts that have been developed within these approaches. The fourth major section of the paper then summarises what has come to be understood about the nature of various *resistances* and their quantitative importance in determining trade flows.

II. *The Gravity Model Approach to Trade Analysis*

Tinbergen's[10] pioneering use of the *gravity model* made bilateral trade levels a function of two potential trade variables (gross national product of importing and exporting countries) and three resistance variables (distance, a dummy variable for adjacent countries and a dummy variable for common membership of a preferential area).[11]

[10] J. Tinbergen, [57, 1962, Appendix VI, pp. 262–93].

[11] Tinbergen derived parameter estimates for the following equation:

$$E_{ij}=a_0 Y_i^{a1} Y_j^{a2} D_{ij}^{a3} N^{a4} P^{a5}$$

where E_{ij} is exports from country i to country j,
Y_i is GNP of exporting country,
Y_j is GNP of importing country,
D_{ij} is distance between country i and country j,
N is a dummy variable for adjacent countries,
P is a dummy variable for common membership of a preferential tariff area,
a_0 is a constant.

Linnemann[12] elaborated the Tinbergen model by introducing additional potential trade and resistance variables into the analysis. The most important was a complementarity variable, measured by the scalar product of the two vectors representing the commodity composition of the exporting country's total exports and the commodity composition of the importing coyntry's total imports.

Two interesting features of the Linnemann results were the tendency for the distance coefficient to take on a higher value for more isolated countries, and the absence of any clear association between the importance of transport costs as an explanator of trade flows and the importance of high transport cost bulk commodities in countries' trade.[13] The latter phenomenon suggests that the effect of distance in lowering trade levels may operate through factors other than transport costs.

The *gravity model* is a very ambitious approach to analysis of the effects of trade resistances, and its ambition raises two important problems. Difficulties in measuring 'potential trade' affect the levels of trade explained by reference to resistance variables and so obscure the relationship between resistances and bilateral trade levels. Of more fundamental importance, the assumption of independent bilateral trade flows is extreme.

Several characteristics of Linnemann's own results seem to be explained best in terms of interdependence among bilateral flows. The tendency for the distance coefficient in the Linnemann regressions to take higher values for countries in more isolated locations[14] suggests that *relative* distance is important in the determination of trade levels. Two close countries at the periphery of the world economy (say, Australia and New Zealand) *relatively* are closer to each other than two similarly proximate countries in Western Europe. The discontinuity in the bilateral trade data observed by Linnemann, with parameter values that were consistent with larger trade flows overestimating smaller flows,[15] is open to the possible explanation that scale factors raise larger trade flows partly by diverting trade from smaller flows. But Linnemann discussed the possibility of interdependence among variances of trade flows (or diversion of trade from high resistance to low resistance routes) in relation to the effects of membership of preferential areas. Evidence presented on this question does not allay doubts that the high levels of trade observed on intra-area trade routes have resulted in considerable part from diversion of trade from non-preferential routes.[16]

Linnemann did not publish individual countries' coefficients for the commodity composition variable. However, there is no *a priori* reason why the coefficients as he defined them should take on more extreme values for countries whose foreign trade was concentrated in commodities that held small shares in world trade. His complementary index, like the distance variable, fails to take account of *relative* 'closeness.' Yet it is clear that the likelihood of country i exporting a given shipment of commodity k to country j depends on the availability of alternative supplies: the smaller country j's share in world exports, the less likely it is that a particular export consignment of commodity k from country i would be sent to j. Leamer and Stern err in arguing that the Linnemann complementarity index

[12] H. Linnemann, [43, 1966]. P. Poyhonen, [46, 1963]. P. Poyhonen [47, 1963], and K. Pulliainen, [48, 1963], are three studies in the same tradition.

[13] The latter conclusion should be treated with extreme caution because of the high degree of aggregation in commodity classes defined for the test.

[14] H. Linnemann, [43, 1966, pp. 91–2].

[15] *Ibid.*, p. 171.

[16] *Ibid.*, pp. 192–4.

C_{ij} may be close to a weighted inner product C^*_{ij}, where the weight of each commodity is in inverse proportion to its share of world trade.[17]

Indeed, a weighting of commodities in the complementarity index according to their uniqueness in world trade would contradict the independence assumption of the *gravity model*.[18]

Wolf and Weinschrott[19] have applied the *gravity model* to identify bilateral trading arrangements which are characterised by high potential for, and low resistances to trade, with a view to assessing the benefits from trading partners' incorporation within a free trade area or other multi-country association. Their model is distinguished by the incorporation of several variables designed to measure differences in 'natural' comparative advantage, and of a variable designed to measure socio-cultural 'distance.'[20] They conclude that the structural relations in the model (as measured by the various coefficients) are stable in the

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[17] E. L. Leamer and R. M. Stern, [42, 1970, p. 165] postulated the following relationship between bilateral trade flows and potential trade and trade resistances.

$$V_{ij}=\frac{F_iF_jg(R_{ij})}{W} \tag{1}$$

where V_{ij} is the level of exports from country i to country j
F_i is the level of country i's exports,
F_j is the level of country j's imports, and
R_{ij} is the variable representing resistances to trade between i and j, and W is total world trade.
Aggregating over commodities,

$$V_{ij}=\sum_k \frac{F^X_{ik}F^M_{jk}g(R_{ijk})}{W_k} \tag{2}$$

where F^X_{ik} is the export supply of the kth commodity by the ith country,
F^M_{jk} is the import demand of the jth country,
R_{ijk} is the trade resistance specific to the kth commodity, and
W_k is the world value of k-commodity trade.
Equation (2) was altered as follows:

$$V_{ij}=\frac{F_iF_jg(R_{ij})}{W}\ \frac{F^X_{ik}F^M_{jk}g(R_{ijk})}{F_iF_jg(R_{ij})}\cdot\frac{W_k^{-1}}{W} \tag{3}$$

$$=\frac{F_iF_jg(R_{ij})\cdot C^*_{ij}}{W} \text{ with } C^*_{ij}=\sum_k\frac{F^X_{ik}F^M_{jk}g(R_{ijk})}{F_iF_jg(R_{ij})}\cdot\frac{W_k^{-1}}{W}$$

Leamer and Stern suggested that $\frac{W}{W_k}$ and $\frac{g(R_{ijk})}{g(R_{ij})}$ would affect trade levels in opposite directions because '...resistance to trade is least [large $g(R_{ijk})$] for commodities that from the bulk of world trade.'

But the term $g(R_{ij})$ introduced into equation (3) has no meaning without specification of a weighting for resistances to trade in different commodities, making the step taken in (3) invalid. If it is assumed that resistances were the same for all commodities, the weighting of commodities would not be relevant. In this case, the term $\frac{g(R_{ijk})}{g(R_{ij})}$ would fall out of equation (3), and the complementarity index would weight commodities in inverse proportion to their shares in world trade. Resulting values of the index are likely to be very different from those of the unweighted (Linnemann) index.

[18] The use of the Linnemann complementarity index also contradicts the independence assumption. Presumably, it was partly for this reason that Linnemann stated that a 'potential complementarity' index would be superior if it could be defined.

[19] C. Wolf Jr. and D. Weinschrott, [64, 1973].

[20] The Wolf and Weinschrott model is:

$$x_{ij} = aY^{\alpha}_iY^{\beta}_jD^{\tau}_{ij}e^{\lambda\sigma}+\phi S_1+\delta S_2+\rho S_3+u$$

where X_{ij} =exports in dollars from i to j (i=1,2,..., n; j=1, 2, ..., n—1),
Y_i =GNP for i (in dollars); Y_j=GNP for j (in dollars),
D_{ij} =geographical distance from i to j (in nautical miles),

short and medium term; that the proxy variables included to capture differences in 'natural' comparative advantage have some explanatory power; and that the socio-cultural dummy variables are in most cases significant. One interesting further conclusion is that the largest negative residuals are usually found in trading relationships between countries that are separated by great distance.

Bryan[21] has estimated parameters for a gravity model by examining the experience of Canada's bilateral trade with various countries disaggregated by commodity. The relative importance of various *trade potential* and *resistance* factors varied considerably across commodities, with special attention being given to international transport costs. Transport costs are more significant determinants of bilateral trade levels in some commodities (especially primary, simply processed and other more homogeneous products) than in others (especially highly differentiated manufactured goods). One interesting conclusion is that international transport costs are generally more important determinants of bilateral trade flows than tariffs.

Leamer[22] uses the framework laid out in his earlier work with Stern[23] to test the adequacy of traditional trade theory, alongside more recent theory which stresses the importance of scale economies, and resistances in determining the commodity composition of trade in manufactures. He concludes that trade dependence ratios are best explained by the development variables, GNP and population, but that when the development group is constrained to *per capita* GNP, 'the resistance factors of tariffs and distance offer nearly the same predictive accuracy for many commodities.'[24] Resource endowment variables do not perform well as explanators of import dependence ratios in the manufactured goods trade.

In the most recent contribution in the *gravity model* tradition, Geraci and Prewo[25] use a sophisticated version of the familiar model to demonstrate that the use of an estimate of actual transport costs gives significantly better results than the use of a distance proxy.

III. *Analysis of Trade Intensity*

1. *Intensity indexes*

A separate line of analysis was pioneered by Brown[26] and developed and popularised

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C = dummy variable relating to socio-cultural 'distance.' (C is a vector of three (0, 1) variables. If i and j have the same primary language, $C_1=1$; if language matches, $C_3=1$. Otherwise the dummies have zero values.)

$S_1 = \frac{\sum_{j=1}^{n=1} X_{ij}}{Y_i}$ (proxy for economic structure)

$S_2 = \frac{\text{Per capita income } (i)}{\text{Per capita income } (j)}$

$S_3 = \frac{\text{Per cent labour force in agriculture } (i)}{\text{Per cent labour force in agriculture } (j)}$

u is a random error term.

[21] I. A. Bryan, [8, 1974].
[22] E. L. Leamer, [41, 1974].
[23] E. L. Leamer and Robert M. Stern, A[42, 1970].
[24] E. L. Leamer, [41, 1974, p. 372].
[25] V. J. Geraci and W. Prewo, [26, 1977].
[26] A. J. Brown [7, 1949].

by Kojima,[27] using an *intensity of trade* index which concentrates attention on variations in bilateral trade levels that result from differential resistances, by abstracting from the effects of the size of the exporting and importing countries. As modified by Kojima, the index I_{ij} takes the form

$$(1) \qquad I_{ij}=\frac{X_{ij}}{X_i}\Big/\frac{M_j}{M_w-M_i}$$

where X_{ij} is country i's exports to country j
X_i is i's total exports
M_j is j's total imports,
M_i is i's total imports, and
M_w is total world imports.

M_i is subtracted from M_w in the above expression because a country cannot export goods to itself, and the only share it can meaningfully have in total world trade is a share in the imports of all countries other than itself.[28]

The intensity of trade index is a crude index of relative resistances because it fails to make allowance for the varying commodity composition of countries' foreign trade. Where commodities are not substitutable for each other, opportunities for bilateral trade are limited by the degree of complementarity in the commodity composition of one country's exports and the other's imports. Drysdale refined the intensity of trade indexes by developing new indexes that separate the effects of the commodity composition of countries' foreign trade (complementarity) from other factors influencing the intensity of trade.[29] The complementarity index, unlike that of Linnemann, takes account of the closeness of countries' commodity trade structures *relative* to world trade structure.

Drysdale's index of *complementarity* in country i's exports to country j, C_{ij}, is the weighted sum of the products of each commodity's share in country i's exports and in country j's imports, with commodities weighted by the inverse of their shares in world trade. The weighting reflects the increased probability of country j drawing a consignment of commodity k from country i when alternative sources of supply are more limited.

$$(2) \qquad C_{ij}=\sum_k\left(\frac{X_i^k}{X_i}\cdot\frac{M_w-M_i}{M_w^k-M_i^k}\cdot\frac{M_j^k}{M_j}\right)$$

where X_i^k is country i's exports of commodity k,
M_j^k is country j's imports of commodity k, and
M_w^k is world imports of commodity k.

The complementarity index C_{ij} indicates the value that the intensity index I_{ij} would take if i's exports of each commodity k were distributed among world import markets exactly in proportion to each market's share of world imports of commodity k.

Drysdale defined an index of *country bias*, B_{ij}^k in trade *for each commodity* analogously to the intensity index.

$$(3) \qquad B_{ij}^k=\frac{X_{ij}^k}{X_i^k}\Big/\frac{M_j^k}{M_w^k-M_i^k}$$

[27] K. Kojima, [38, 1964]. See also K. Kojima [37, 1962, Chap. 7].
[28] Cf. I. K. Savage and K. W. Deutsch, [52, 1960, p. 552].
[29] P. D. Drysdale, [21, 1967]. See also P. D. Drysdale [19, 1969, pp. 321–42].

where X_{ij}^k is country i's exports of commodity k to country j. A weighted average of indexes of country bias *for all commodities* k yields an index B_{ij} of country bias in i's aggregate export trade with j.

$$B_{ij} = \sum_k \left(B_{ij}^k \frac{\bar{X}_{ij}^k}{\bar{X}_{ij}} \right) \quad , \tag{4}$$

where $\bar{X}_{ij}^k$ is the hypothetical value of X_{ij}^k obtaining when B_{ij}^k equals unity, and $\bar{X}_{ij}$ is the hypothetical value of X_{ij} obtaining when all B_{ij}^k equal unity. The ratio $\frac{\bar{X}_{ij}^k}{\bar{X}_{ij}}$ is equal to the percentage contribution of commodity k to complementarity in i's exports to j.

The indexes C_{ij} and B_{ij} are so defined that their product equals I_{ij}.

$$I_{ij} = C_{ij} \cdot B_{ij} \tag{5}$$

The effect of the commodity composition of countries' trade on intensity of trade is measured by the complementarity index. The country bias index B_{ij} measures the *average* effect of differential resistances on intensity in bilateral trade. Among the difficulties associated with Drysdale's decomposition of trade intensity into complementarity and country bias elements is the assumption that the commodity composition of each country's global trade is, in the extrene, independent of influences affecting bilateral trade. It is quite conceivable that, for example, changes in a tariff or the structure of transport costs would have effects on import specialisation and complementarity as well as country bias in trade. If there were many such cases, the distinction between country vias and complementarity would be blurred.[30]

The importance of different resistances varies from commodity to commodity and it is not uncommon for a certain resistance (say, transport costs) to be relatively high for exports of one commodity from country i to country j, but to be relatively low for other commodities in the same bilateral flow. Thus, although the aggregate country bias index B_{ij} is a useful summary of the effects of a range of resistance influences, it needs to be supplemented by the disaggregated indexes B_{ij}^k in a detailed study of the nature of resistances to bilateral trade flows. Country bias indexes for individual commodities are a reliable reflection of the ordering of relative resistances in various bilateral trade flows so long as the commodity classification used identifies homogeneous commodities that are not substitutable for each other.[31]

More recently Kunimoto[32] has attempted a taxonomy of trade intensity measures using statistical contingency table analysis as an integrating framework. In describing the logic of the various indexes that have been used in the work on the analysis of bilateral trade flows, he makes no comment on their economic meaning or analytic value but observes that 'it is not possible *a priori* to say which index is best suited for the analysis of international trade flows . . . (and) therefore, the choice of index hinges on the nature of the problem to be tackled.'[33] However, in his work Kunimoto introduces what he considers to be a new

[30] P. D. Drysdale, [21, 1967, pp. 33–4].

[31] For a detailed discussion of the effects of the commodity classification on the indexes see R. Garnaut, [25, 1972, Chap. 3].

[32] K. Kunimoto, [40, 1977] based on his doctoral dissertation, [39, 1975].

[33] *Ibid.*, p. 30.

index of trade intensity which is in fact a contingency table formulation of Drysdale's complementarity index.[34]

The *intensity approach* acknowledges the interdependence of levels of bilateral trade on different routes. Although it does *not* seek to answer important questions about the effects of resistances on countries' total exports and imports, it has major advantages as a starting point for analysis of the nature of resistances to trade flows. Country export and import totals are given, in aggregate or by commodity, and so the *intensity approach* abstracts from the effects of excluded variables and random fluctuations on 'potential trade,' which distort the magnitudes to be explained by resistances in the *gravity model.*

An assumption that all countries' imports and exports are made up of large numbers of independent consignments underlies the intensity approach.[35] Let country i have a share in world exports x_i. This equals $\frac{X_i}{W}$ where X_i is country i's total exports and W is total world trade. The probability that any trade transaction in the world involves country i as exporter is x_i. Similarly, the probability that j is the home of the importer is m_j, the ratio that j's imports bear to total world trade.[36]

The probability that a particular transaction will involve two given countries is negatively related to relative resistances to bilateral trade. Deviations from 'expected' levels of bilateral trade occur because resistances vary among bilateral trading relationships. Ratios of actual to expected levels of bilateral trade below unity are associated with high relative resistances and ratios above unity with low relative resistances. Where they are expressed in volumes or value of trade, positive deviations are associated with low relative resistances and negative deviations with high relative resistances.

2. *Intensity indexes and the analysis of trade resistances*

Several studies have employed forms of the intensity indexes introduced above as indicators of relative resistances to bilateral trade flows, and have analysed the nature and importance of various resistance factors by explaining variations in the indexes over time and across bilateral trading relationships. Other studies have employed the intensity of trade *concept* for this purpose, without using explicitly an intensity index. Here we survey some conclusions about the nature of resistances that have emerged from this literature.

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[34] Kunimoto's index *Iijk(e)* reduces to C_{ij} defined above. Compare K. Kunimoto [40, 1977, pp. 29–31 and P. D. Drysdale, [21, 1967, pp. 23–5]. J. E. Roemer, [49, 1976] also investigated the properties of the various concepts of trade intensity but his survey is less complete than that of Kunimoto, although it introduces new terminology.

[35] The probability basis of the *intensity approach* is made explicit in E. L. Leamer and R. M. Stern, [42, 1970, p. 160]. Similar ideas were introduced in I. R. Savage and K. W. Deutsch, [52, 1960].

[36] In a world economy in which resistances were equal on all trading routes, the probability P_{ij} that a particular transaction takes place between i and j is given by $P_{ij}=x_i m_j$. Thus the expected flow x_{ij} from i to j is

$$x_{ij} = x_i m_j NB = \frac{X_i M_j}{W}$$

Where N is the number of consignments in world trade and B is the value of each consignment. In this formulation, the value of all consignments is assumed to be the same. But the conceptual basis of the *intensity approach* remains valid if consignment are not equal, so long as none is large relative to the trade of the importing and exporting countries. Cf. I. K. Savage and K. W. Deutsch, [52, 1960, pp. 554–5].

Drysdale[37] examined variations in the complementarity and country bias index in trade between Australia and Japan over the half century from 1913 to 1962. Large variations in the country bias index through this period were associated with major changes in the external political relationships of one or other country and, significantly with the increase in mutual knowledge of each other's markets and trading institutions through the postwar period.

Two publications by Yamazawa explored characteristics of the complementarity and country bias indexes.[38] The first of these studies observed changes over time and association between levels taken by the two indexes. The second tested the relationship between intensity of trade and resistance variables and complementarity by the use of least squares regression techniques.

Yamazawa's second study estimated parameters of a log-linear equation relating complementarity as meausred by the Drysdale index and a large number of resistance variables to intensity of trade.[39] Apart from the use of the complementarity index, unique features of the analysis included the use of a *relative* distance variable, inclusion of a variable representing official aid flows, and inclusion of a wider range of trading *blocs*.

The overall fit between the estimated equation and the data was diasppointing, especially since a large part of the multiple correlation was accounted for by the complementarity variable. Only a small fraction of the variance of *country bias* appears to be explained by the measures or indexes of resistances incorporated in the Yamazawa study. Five of the nine independent variables were significant and all of these showed the sign expected from *a priori* reasoning: complementarity; relative distance; the dummy variable representing common membership of colonial trading *blocs*; the dummy variable representing common membership of the socialist trading *bloc*; and the dummy variable that was assigned a non-zero value if one trading partner was a socialist and one a capitalist country. The coefficient of the dummy variable representing common membership of colonial trading blocs took on a lower value in 1965–7 than in earlier years, indicating the declining importance of such ties over time.

Some of the Yamazawa variables could be refined so as to reflect more faithfully the levels of the relative resistances they represent. Yamazawa's relative distance variable is not weighted by the weighted sum of the distance between all pairs of trading partners, as is

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[37] P. D. Drysdale, [21, 1967].

[38] I. Yamazawa, [65, 1970] and I. Yamazawa, [66, 1971].

[39] I. Yamazawa, [66, 1971]. Parameters were estimated for the following equation:

$$I_{ij}=a_0 \cdot N_{ij}^{a1} \cdot D_{ij}^{a2} \cdot Y_{ij}^{a3} \cdot A_{ij}^{a4} \cdot P_{ij}^{1a5} \cdot P_{ij}^{2a6} \cdot P_{ij}^{3a7} \cdot P_{ij}^{4a8} \cdot P_{ij}^{5a9}$$

where a_0 is a constant

$D_{ij}(=D_{ji})$ is an index of relative distance, defined as $\frac{d_{ij}}{14\sqrt{(\sum_i d_{ij})(\sum_j d_{ij})}}$; d_{ij} is the distance between country i and country j.

$Y_{ij}(=Y_{ji})$, defined as $\frac{\text{min. } (Y_i, Y_j)}{\text{max. } (Y_i, Y_j)}$; Y_i is per capita income in country i and Y_j per capita income in country j.

A_{ij} is an index of intensity of aid flows from i to j, defined as $\frac{a_{ij}}{a_i} \cdot \frac{a}{a_j}$; a_{ij} is the value of intergovernmental 'loans' from i to j, a_i is the total 'aid' received by j, a the world total of aid flows.

P_{ij}^1, P_{ij}^2, P_{ij}^3, P_{ij}^4, P_{ij}^5, are dummy variables introduced to stand for membership of trading *blocs*.

necessary to preserve the logic of the *intensity approach*.[40] The index of 'aid' flows covers only the less important types of international capital flows, and it is not surprising that it was swamped by other influences. However, these and other refinements of the variables are likely to raise the correlation coefficient only marginally. As an analysis of trade resistances, the Yamazawa study employed more satisfactory concepts than those used in any other econometric work to that time,[41] yet the analysed variables accounted for a very small part of the variance in country bias in trade.

Garnaut[42] used the aggregate and commodity-specific country bias index to generate an ordering of relative resistances across the bilateral trade relationships between Australia and each of the five member countries of the Association of Southeast Asian Nations. Despite the similar geographic location of the five Southeast Asian countries, there were large differences in the total and disaggregated indexes across the five trading relationships. The effects of the *objective resistances*, transport costs and protection, were calculated by statistical methods. The case study method, involving interviews with company executives involved in trading decisions, was then employed to attribute the inexplained variation in country bias to various *subjective resistances*. This study revealed that the preferences of ultimate users were important in determining bilateral trade patterns in highly differentiated commodities, but not in more homogenous commodities. For the latter, biases in the trade decision-making processes of companies were of considerable importance. For affiliates of multinational enterprises, which accounted for a substantial part of Australian and Southeast Asian foreign trade, there was a high degree of intra-company trade, so that the location of affiliates was a major determinant of bilateral trade patterns. For independent enterprises, the particular order in which pioneering trading firms searched the international environment for trading opportunities was of considerable importance, especially since many firms relied heavily upon other trading firms in their own country for leads on new markets. Explicit internal constraints on profit maximising behaviour appeared relatively unimportant in the determination of trading patterns.

Interactions among the various types of resistances, and between complementarity and country size, were analysed and appeared to be very important to the explanation of variations in country bias. In most cases, *subjective resistances* tended to reinforce the effects of *objective resistances*, with the former being of greater direct importance for more differentiated commodities and the latter for more homogeneous commodities. The presence of economies of scale in overcoming all resistances to bilateral trade meant that there was considerable multicollinearity amongst values taken by the various resistance variables. These economies of scale, together with high external costs of pioneering new trade links, were seen to be major factors in explaining the observed stability in country bias over time.

Two factors seem to have been of particular importance in determining country bias levels: distance; and common former membership of imperial trading blocs. Both influenced

[40] The correct form of the relative distance variable D_{ij} is

$$D_{ij}=\frac{d_{ij}(\sum_i\sum_j(d_{ij})\,(x_i\cdot m_j))}{(\sum_i(d_{ij})\,(x_i m_j))\,(\sum_j(d_{ij})\,(x_i m_j))}$$

[41] Higher correlation coefficients in the *gravity model* studies are misleading, because much of the variance of *total bilateral trade flows* 'explained' by the independent variables is accounted for by variation in the size of the trading partners.

[42] R. G. Garnaut, [25, 1972]'

the order in which traders searched the international market, patterns of multinational investment and transport costs. Preferential import restrictions dating mainly from the thirties promoted intra-imperial trade, which continued with high intensity after the cessation of the preference, but increasingly less powerfully over time. The decline in importance of the old imperial *blocs* caused relative distance to emerge more powerfully as a determinant of country bias in trade.

In analysing the effects of international ownership ties on bilateral trade flows, an index of ownership compatibility was developed, consistently with the logic of the intensity approach.[43] This index explained a high proportion of variations in country bias in those commodities in which a high proportion of trade was conducted within multinational corporations, notably the petroleum trade.

Three recent studies have applied the intensity of trade and one of them a modified intensity of trade index, to the analysis of the effects of political *blocs* on levels of bilateral trade. The method of these studies was pioneered by Girgis,[44] who sought to answer the question whether trade between Arab countries and various external countries was more or less intense than might be expected *a priori* from the countries' position in world trade.

Girgis recognised that the particular commodity composition of two countries' foreign trade might cause the index of trade intensity between them to take values away from unity, independently of the effects of those factors which we have described as *resistances*, although he does not control for this by the use of a precise measure of complementarity. Girgis is interested in intensity in bilateral trading relationships which involve one developed and one developing country. He argues that there are consistent differences between the commodity composition of the trade of less developed countries and that of the world as a whole. Deviations from unity in the aggregate intensity of trade index can then be expected simply as a result of these variations in 'complementarity.' Thus he employs as an index of intensity of trade between one developed and one developing country the product of the bilateral trade level's share of the developing country's total trade, and the developed country's share of the total trade of developing countries. The Girgis index of trade intensity compares the developed country's share of the trade of the particular developing country with its share of the trade of developing countries as a whole.

The diversity of developing countries' patterns of export specialisation creates diffi-

[43] The *ownership compatibility* index O_{ij} is given by

$$O_{ijk}=\sum_{F=1}^{n}\left(\frac{X_i^{kf}}{X_i^k}\cdot\frac{(M_w^k-M_i^k)}{(M_w^{kf}-M_i^{kf}}\cdot\frac{M_j^{kf}}{M_j}\right)$$

where X_i^f is company f's exports of commodity k from country i,
X_i^k is total exports of commodity k from country i,
M_w^k is total world imports of commodity k,
M_i^k is total imports of commodity k into country i,
M_w^{kf} is company f's total, worldwide imports of commodity k,
M_i^{kf} is company f's imports of commodity k into country i,
M_j^{kf} is company f's imports of commodity k into country j,
M_j^k is total imports of commodity k into country j.

Parry has employed a similar concept to examine the foreign investment-related competitiveness of United States manufacturing industry, using the first two elements in the above expression to define an index of revealed 'non-trade performance' or foreign-affiliation related performance in exporting by U.S. firms. See T. G. Parry, [45, 1975].

[44] M. Girgis, [28, 1973]. E. Kleiman, [36, 1976]. E. Kleiman, [35, 1978].

culties for the use of this method.[45] Take the important case of a developed country that has large domestic oil production (perhaps the United Kingdom) and a developing country heavily specialised in oil exports (one of the OPEC countries). Trade intensity measured by the aggregate index will be very low because of very low complementarity. The Girgis correction will yield an even lower intensity value in the common case (again, the United Kingdom) where the developed country's share of the exports of developing countries is greater than its share of total world exports. This is not to argue that the Girgis index is not more satisfactory on average as an index of relative resistances in developed-developing country trade than an aggregate intensity index. But it is certainly less satisfactory than the country bias index, which adjusts precisely for any peculiarities of the two countries' commodity specialisation in world trade.

Kleiman[46] has applied a similar approach in analysing the impact of colonial political relationships on bilateral trade patterns. Kleiman compares the metropolitan country's share of the colony's (or ex-colony's) trade with that of a control group of countries, the metropole's trade share of which could have been expected to be similar to that of the colony in the absence of the colonial tie. In one case, he uses the metropole's share in the trade of African dependencies as a whole as his control group.[47] An identical approach, with similar advantages and disadvantages, was employed in a study of the effects of the residual ex-colonial cultural ties on trade between Spain and the former Spanish Latin America.[48] In this case, the ex-Portuguese colony of Brazil was used as the control group. This approach suffers from its failure to allow precisely for differing complementarity in trade, and introduces a new consistent bias in the comparisons to the extent that colonialism caused each of the metropolitan countries' trade with Africa as a whole to be more intense than it would otherwise have been. However, it does have advantages as an approach to the identification of the effects of one particular source of relatively low *resistances* to bilateral trade, colonial ties, to the extent that its use of adjacent territories (in Africa) as a control group reduces the differential effect on trade intensity of one other source of relatively low resistances, geographic distance.

The approach used by Girgis and Kleiman is in fact very similar to Kojima's earlier use of intensity indexes to analyse the factors underlying resistances to regional trade flows in Asia and the Pacific.[49]

The substantive conclusions of the Girgis-Kleiman papers are of some interest, despite some lack of precision of their method. Girgis observed some tendency over time towards multilateralisation of Arab countries' trade relations, although political conflicts between pairs of countries were a source of sudden large falls from time to time in values of the indices. Kleiman observed in his *Economic Journal* article that colonial ties raised the volume of trade between metropole and colony by at least several times, and that this remains with diminishing effect over about two decades from Independence. In his later article, Kleiman concluded that the residual cultural heritage of Spanish colonialism now had very little effect in promoting trade between Spain and former Spanish colonies in Latin America.

[45] For an illustration of the highly diverse pattern of developing country export specialisation and its effect on complementarity with various developed countries, see P. D. Drysdale, [19, 1969].

[46] E. Kleiman, [36, 1976] and [35, 1978].

[47] E. Kleiman, [36, 1976].

[48] E. Kleiman, [35, 1978].

[49] K. Kojima, [37, 1962].

The use of more precise methods and a more complete conceptual framework of analysis would change the magnitudes associated with these conclusions as well as encourage more qualified judgments about the dominance of particular resistance factors, for example Kleiman's conclusions on Spain's trade with Latin America, but it would not affect their general thrust.

A number of studies have measured changes in trade intensities simply to demonstrate the changes in the geographic structure of trade in the postwar period[50] or the effects of customs union and free trade associations on the value of intensities.[51] A more ambitious study by Roemer[52] employs the intensity, complementarity and country bias concepts to explore the effects of 'sphere of influence' and economic distance on the commodity composition of trade in manufactures. He observes that exporters of manufactured goods tend to market their less competitive manufactures disproportionately in the geographic areas of strongest relative market share, and that this phenomenon cannot be accounted for entirely by transportation costs. He suggests that it is due largely to 'sphere of influence factors: supra-market, historical factors that give exporters trading advantages in some areas that other exporters do not have . . .'.[53] Importantly Roemer notes the difficulty of separating 'sphere of influence' factors from distance factors in the explanation of country bias in manufactured goods trade although no attempt is made to theorise about the interaction between the two factors.

Another area of research within the *intensity approach* (that is, analysing the determinants of bilateral trade given country totals), but incorporating some of the method of the *gravity model*, was opened up by Tilton. Tilton[54] used linear programming techniques to test association between actual patterns of bilateral trade, null (equal resistance) patterns of trade and the pattern of trade that would minimise total 'transport costs,' for a range of minerals and metals.[55] Focus on individual commodities rather than total trade abstracted from the effects of commodity composition on trade intensity. The effect of differentiation of the individual commodities was very slight, since the minerals and metals studied were relatively homogeneous. Transport costs were a significant determinant of bilateral trade flows. Other *resistances* (ownership ties, trading blocs) commonly exercised significant pressures in a direction opposite to those of transport costs.

Tilton supplemented his linear programming analysis with an econometric study that

[50] See W. T. Wilford and G. C. Christou, [63, 1976].

[51] See M. K. Carney, [9, 1970], and W. T. Wilford and G. Christou, [62, 1976].

[52] J. E. Roemer, [50, 1977].

[53] *Ibid.*, p. 327.

[54] J. E. Tilton, [55, 1976, p. 419]. The article is taken from a doctoral dissertation by the same title (Yale University, New Haven, 1966), which includes in addition an important Appendix III, entitled 'The Non-Price Factors: A General Descriptive Analysis.' The thesis is available in microfilm. Further references are to the published material unless otherwise stated.

[55] The linear programming model specified that x_{ij} matrix which minimised $\sum_i \sum_j t_{ij} x_{ij}$, where t_{ij} was the per unit cost of transporting commodity z from country i to country j and satisfied the restrictions:

(1) $\sum_j x_{ij} = x_i$

(2) $\sum_i x_{ij} = M_j$

(3) $x_{ij} \geqq \theta$

(4) $x_{ij} = 0$ when country i is j.

Bilateral transport costs t_{ij} were obtained from trading companies and fed into the model.

incorporated characteristics of both *gravity and intensity approaches.*[56] The study had several unsatisfactory features,[57] but it did point to ownership ties between exporting and importing firms in different countries as having a very important influence on trade patterns.[58]

Tilton and his associates have refined the original work in a series of papers employing the *gravity model* methodology, surveyed recently by Demler and Tilton.[59] All of these studies find that ownership ties greatly influence minerals and metals trade flows, especially at the ores and concentrates stage of metals production. There has been some decline over time in the importance of ownership ties, but they remain very significant. The old colonial *blocs* continue to have a significant effect on bilateral trade in meinrals. Distance has an important effect, but one that is uneven across commodities, and that is clearly less significant than ownership ties.

IV. *The Use of Intensity Indexes in Projections*

Whereas the studies discussed above sought on analyse resistances to bilateral trade and to explain the contribution of resistances to the formation of trade patterns, other studies have defined and measured bilateral trade intensity and projected bilateral trade flows on the basis of assumptions of stable trade intensities.

Uribe, de Leeuw and Thiel[60] used a concept identical to the Brown-Kojima index of

[56] Firms' total exports and imports of each commodity were included as independent variables. Most of the independent resistance variables were measures of absolute resistances, but a very interesting measure of *relative* transport costs was used. The transport cost variable t_{ij} was the excess cost of distorting the 'minimum cost' pattern of bilateral trade to allow exports from i to j, Where exports from i to j were specified in the minimum transport cost pattern of trade, the variable took a zero value.

[57] Most importantly, a linear relationship was postulated between dependent and independent variables. A log-linear equation would seem to fit expectations of the relationships in a more satisfactory way. Tilton eschewed use of log-linear equations because continuous variables included in the analysis assume zero values for some observations. But it would seem to be possible to change the basis of the variables to avoid this problem. Multicollinearity, a problem in all econometric studies of determinants of trade flows, is a larger problem in the Tilton study, because of the nature of the 'size of the country' variables.

[58] Least squares regression techniques were used to estimate parameters of the following equation:

$$x_{ij}=a_0+(a_1+a'_4A'=a'_5B'+a'_6D'+a'_7E'+a'_8F')X_i+(a_2+a''_4A''+a''_5B''+a''_6D''+a''_7E''+a''_8F'')M_j+a_3t_{ij}+a_9O_{ij}$$

where x_{ij} was exports from country i to country j,

x_i was total exports of country i, and

t_{ij} was transport costs from country i to country j.

Variables x_{ij}, X_i and M_i were expressed in units of one thousand tons. The parameter a_3 was defined to indicate in thousands of tons how much trade between i and j would fall (rise) when the difference in cost between shipping a ton over the 'direct' and 'minimum cost indirect' routes between the two countries increased (decreased) by one cent. Variables A to F referred to membership of political *blocs* and were represented by dummy variables that took values of unity when both countries were members of the *bloc* under consideration, and zero when they were not. The variable O_{ij} indicated the volume of exports from country i controlled by interests in country j. Ownership ties exerted the strongest influence on levels of trade amongst variables examined. The estimates of a_9 were large and, except for zinc metal, tin metal and tin concentrate, significant. Common membership of political *blocs* appeared to be very important for metal trade, but not ore trade. Strangely, parameter estimates for the transport costs variable were small and not significant (J. E. Tilton, [55, 1976, pp. 447–65]). Coefficients of determination were generally low.

[59] F. R. Demler and J. E. Tilton, [16, 1978]. See also A. L. Dorr, [17, 1975], D. A. Hubbard; [31, 1975]; T. M. Santos, [51, 1976]; J. E. Tilton and A. L. Dorr, [56, 1975].

[60] P. Uribe, C. J. de Leeuw and H. Thiel, [1966].

trade intensity as the basis for predicting future trade flows from knowledge of import and export totals. Their first step is to compute forecasts on the assumption of constant mutual information values (trade intensities) and subsequently to adjust these preliminary forecasts to satisfy the marginal constraints and minimise information inaccuracy. They observe similarity between Waelbroeck's[61] earlier use of the RAS method to analyse world trade flows and their use of the information criterion when forecast bilateral flows do not violate the marginal constraints seriously.[62]

Drysdale[63] has used indexes of trade intensity as well as his complementarity and country bias indexes to project bilateral trade flows, given forecast country and world trade totals, in a partial frame. Some of these projections were based on the assumption of constant trade intensity, but with others, information about changes in the structure of complementarity and country bias indexes were also introduced in an attempt to improve the forecasts. No attempt was made in his work to achieve a complete or mutually consistent set of forecast trade flows.

Cuddy[64] has also developed projections from the concept already familiar as the Brown version of the intensity of trade index, but re-named the 'delta coefficient':

$$\delta_{ij} \equiv \frac{Tx_{ij}}{x_i m_j} \tag{6}$$

where x_i is total exports from country i, m_j is total imports into country j, x_{ij} is the flow of exports from country i to country j and T is total world trade (equal to $\sum_{i=1}^{N} x_i$ if there are N countries). This expression is identical to that in (1) above except that no adjustment has been made to eliminate self imports from the comparisons.

Cuddy goes on to disaggregate the intensity of trade index by commodities:

$$\delta_{ijk} = T^2 \frac{x_{ijk}}{x_i m_j c_k} \tag{7}$$

where x_{ijk} is the value of the flow of trade from i to j in commodity k, c_k is total trade in commodity k and T is total world trade. However, this disaggregation of trade intensity by commodities has serious weaknesses that detract significantly from its usefulness.

As a measure of relative resistances, the disaggregated 'delta-coefficient' is deficient in its failure to take account of the commodity composition of the trading partners' total trade. To demonstrate the deficiency with an extreme example, the trade flow x_{ijk} might comprise the whole of country i's exports and country j's imports of commodity k, and yet the disag-

[61] J. Waelbroeck, [61, 1964].

[62] P. Uribe, C. J. de Leeuw and H. Thiel, [59, 1966], also use the log of the trade intensity index as a means of 'drawing interesting conclusions about changes in trade patterns' (p. 216). Log I_{ij} is zero when country j's share in country i's exports are equal to country j's share in world trade. They appear to assert, wrongly, that deviations from this 'independence' value are likely to occur solely as a result of distance or political resistance (p. 210 and p. 216). For a full review of the literature which appeals to the assumption of stability in market shares in the analysis of international trade, see United Nations, [58, 1973, pp. 2–3].

[63] Commonwealth of Australia, [10, 1965, p. 329]. P. D. Drysdale, [18, 1969], and [22, 1970], and [20, 1972]. J. G. Crawford and S. Okita, [13, 1976] and J. G. Crawford, S. Okita *et al.*, [14, 1978, Chap. 6]. Complementarity and intensity coefficients have also been used by the Japanese Economic Planning Agency, in the analysis of trade performance.

[64] J.D.A. Cuddy, [15, 1973].

gregated 'delta coefficient' might be low, suggesting falsely high relative resistances, if commodity k represents a smaller proportion of the exports of country i and the imports of country j than it does of world trade. The disaggregated country bias index, $B_{ij'}{}^{k}$ defined in (3) above, does not have this defect.

The failure to weight appropriately the commodity composition of the partners' total trade would not be a problem for *projections* of bilateral trade if the share of country i in world exports and of country j in world import of commodity k could be expected to remain stable over the projection period. However, the process of world incomes and trade growth has in fact involved large changes in the patterns of individual countries' export and import specialisation. This transformation has been especially important for the more successful developing countries as well as the fast growing developed countries, and to deny the possibility of major transformation of commodity specialisation is to assume away an important aspect of the process of growth.

Cuddy's projection method is nonetheless original and, if applied cautiously, constitutes a useful methodological advance.[65] Substituting disaggregated country bias indexes $B_{ij}{}^{k}$ for disaggregated 'delta coefficients' δ_{ijk} and using Cuddy's terminology,[66] the projected level of bilateral trade in commodity k, $x_{ijk}{}^{p}$ becomes

$$x_{ijk}{}^{p}=\frac{1}{T^{p2}}\ B_{ijk}{}^{p}x_{ik}{}^{p}c_{k}{}^{p} \tag{8}$$

where the superscript p indicates a projected value. Thus, the bilateral flows are calculated from projections of the structural coefficients and the vectors of total exports and imports by commodity and by country.

After substitution of equation (8) for Cuddy's projection equation derived from (7), Cuddy's method of ensuring mutual consistency among projections can be applied with only minor modification. The accounting restrictions on the projected flows are written:

$$\sum_{j}\frac{x_{ijk}{}^{p}}{T}=\frac{x_{ik}{}^{p}}{T}\quad\text{for each } i \tag{9}$$

$$\sum_{i}\frac{x_{ijk}{}^{p}}{T}=\frac{m_{jk}{}^{p}}{T}\quad\text{for each } j \tag{10}$$

$$\sum_{ij}\frac{x_{ijk}}{T}=\frac{c_{k}{}^{p}}{T}\quad\text{for each } k \tag{11}$$

With this modified method, country export totals $x_{i}{}^{p}$ and import totals $m_{j}{}^{p}$ must be given simultaneously with $x_{ik}{}^{p}$ and $m_{jk}{}^{p}$ and satisfy the restrictions

$$\sum_{k}x_{ki}{}^{p}=x_{i}{}^{p} \tag{12}$$

and

$$\sum_{k}m_{jk}{}^{p}=m_{j}{}^{p} \tag{13}$$

The modified Cuddy method allows separate projections of $B_{ijk'}$ $x_{jk}{}^{p}$ and $c_{k}{}^{p}$ and subsequently the setting up of a mathematical program in which the projected country bias

[65] See J.D.A. Cuddy, [15, 1973, pp. 1223–30].

[66] The superscripts k designating flows by commodity in Cuddy's nomenclature became subscripts and the other terms are as defined for (6) and (7).

indexes vary as necessary to ensure the satisfaction of the accounting relations (9) through (11), subject to a minimum weighted deviation restriction

$$\min \sum_{ijk} |B_{ijk} - B_{ijk}^{p}| r_{ijk} \tag{14}$$

where the weighting factors r_{ijk} reflect an assumption of the improbability of variation from the projected country bias indexes.[67]

Cuddy determined the weightings r_{ijk} as the reciprocals of the standard errors of the log-linear regression of the observed coefficients against time, over the period of observation. We feel that more reliable weightings can be developed, based on established knowledge in the literature on trade resistances. For example, large trade flows are likely to reveal more stable country bias than small flows,[68] other things being equal, and the absence of a factor related to the size of the existing trade flows is likely to place a greater adjustment burden on country bias in the large flows.[69] The weighting r_{ijk} should be heavier for large flows. The variability of country bias depends on the relative uinflence of various types of resistance on country bias in a particular bilateral commodity flow, so that analysis of resistances ia s prerequisite to the specification of more reliable limits. The literature on resistances warns that patterns of relative resistances vary greatly among commodities in a given bilateral trading relationship, even when the commodity classification used is as detailed as the Standard International Trade Classification three-digit (178 commodity) level. Further, geographically proximate countries with similar patterns of trade specialisation reveal widely different relative resistances to trade in a given commodity with a given country outside the region. Thus a high degree of aggregation by commodity or country groups can be expected to reduce greatly the reliability of projections. Projections over longer periods are likely to be very much less reliable than projections over short periods, and the 'ten-to-fifteen year run' is a long period over which to predict relative resistances in bilateral trade.[70]

Here we have been concerned with reviewing only that part of the literature on world trade projections[71] which uses intensity coefficients as an important element in the projection of international trade networks. Other work, which does not attempt to employ the intensity concept to attain consistency in forecasts of trade flows, is not discussed. The world

[67] Frisch was concerned with the observe of a similar problem when he set out to explore the adjustments to bilateral payments ratios that would ensure multilateral payments balance at the optimum trade level. Ragnar Frisch, [23, 1947].

[68] This follows from the importance of economies of scale in transport and in the transfer of information which, in association with the high, external costs of pioneering new trade, can cause country bias to rise and to remain high after some new impetus has induced some trade growth in a previously unimportant trading relationship (see R. G. Garnaut, [25, 1972, Chaps. 8 and 9]). Random variations are also likely to be greater, as a proportion of bilateral trade, in small trade flows, although the Cuddy weighting covers this influence.

[69] It is therefore difficult to accept Cuddy's assurance that Bacharach's criticisms (see M. Bacharach, [4, 1970, pp. 36–7]) do not apply to his model.

[70] Cuddy argues that the '...regulations of GATT, and such international commodity conventions as exist are examples of this kind of constraint on the flexibility of the international trading system, at least in the ten-to-fifteen year run, which represents the middle term for international relations.' [15, 1973, p. 1227]. However, the literature reveals experience of, and the possibility of, quite abrupt and radical changes in important trade flows.

[71] This literature and the various approaches adopted to world trade projections are reviewed fully in United Nations, [58, 1973, pp. 23–4].

trade models of the International Monetary Fund, Project LINK, and the Swiss Federal Institute of Technology represent major contributions in this genre.[72] The structure of these models differs from that discussed here, although these models too aim to generate internally consistent trade flows, taken from national plans or forecasting models, into a coherent international framework. Commonly in these models, total exports and imports for each country (and in disaggregated versions for each commodity group) are determined by linking imports to income or expenditure and relative prices, and exports to imports.[73]

An important purpose of projections of bilateral trade is to illustrate changes in the structure of bilateral trade that are necessary to the realisation of specified trade growth objectives. Patterns of bilateral trade can in some circumstances be changed relatively quickly in response to policy measures relating to shipping routes and transport costs, information flows, ownership ties between exporters and importers, and tariffs and other government imposed or institutional restrictions on trade. Dissection of trade intensities appears as a powerful tool in the analysis of these trade resistances, and useful in the formulation of policy where resistances can be subjected to policy manipulation.[74] Such policy changes require careful planning, often international negotiation and time. But realisation of the need for adjustments in patterns of bilateral trade, an area of international trade policy frequently neglected in the textbooks, can assist in preventing inherited structures of relative resistances to bilateral trade from sabotaging individual countries' plans for growth of foreign trade and incomes.

V. *Conclusions*

This *survey* has sought to digest the considerable literature on the measurement and analysis of bilateral trade flows. It has identified two basic approaches to the question: the *gravity model* approach, which seeks to explain the level of trade conducted between two countries in terms only of the characteristics of the two countries and the strength of obstacles to trade between them; and the *intensity approach* which takes each country's total imports and exports as given, and seeks to explain levels of bilateral trade in terms of the strength of obstacles to trade between other pairs of countries in the world economy.

Each of the two approaches is useful for particular purposes. The *gravity model* approach provides some indication of the importance of *resistances* to bilateral trade as determinants of the total size of a country's foreign trade. The *intensity approach* identifies differentials in *resistances* across various bilateral trade relationships, and the examination of these differentials provides fertile ground for analysis of the nature and relative importance of the various types of *resistance* to trade. The literature covered by this survey demon-

[72] See especially, R. J. Ball (ed.), [5, 1973]. P. S. Armington, [1, 1969] and [2, 1969] which were seminar contributions. B. G. Hickman and L. C. Lau, [30, 1973]. B. G. Hickman, [29, 1973] in R. J. Ball (ed.) [5, 1973]; and G. Taplin, [53, 1973] in R. J. Ball (ed.) [5, 1973] are applications of this approach.

[73] A recent attempt at incorporating the supply side more fully into this kind of model is: V. J. Geraci and W. Prewo, [27, 1978].

[74] The present authors' interest in this analysis was inspired by the study of Australian-Japanese trade flows, Pacific area trade flows, and trade between Southeast Asian countries and their trading partners. The methodology has, of course, rich potential for application in fields other than the analysis of trade flows. It can be used, for example, to analyse market fragmentation and penetration more generally, in the study of migration and factor flows, and in sociological enquiries.

strates that *resistances* to trade are substantial determinants of bilateral trade flows, and indicates the most important resistance factors.

The relative importance of various resistances varies across commodities and with the particular characteristics of a bilateral trading relationship. Studies in both the *gravity model* and *intensity* traditions demonstrate the importance of *distance* and common membership of *imperial trading blocs* to bilateral trade flows, and also the declining importance of the latter influence over time. Early studies tended to see distance and common membership of politico-economic *blocs* as proxies for relatively low transport costs and commercial policy barriers to trade but it has since been shown that these variables are correlated with the cost of overcoming a wide range of objective and subjective *resistances*. Several studies with widely differing approaches have demonstrated important effects of international ownership ties in determining trade patterns. There is considerable evidence of the interdependence of trade levels across bilateral trading relationships and of the interdependence of the costs of overcoming various types of resistance within a single bilateral trading relationship. Patterns of *resistances* to trade, and hence patterns of bilateral trade, tend to be relatively stable over time, and there are important economic reasons why this is so. However, they can change markedly over time in some circumstances, and there is considerable interest in the analysis of the pressures which can generate such change.

The relative stability over time of resistance factors makes various measures of them useful in projections of bilateral trade flows. The intensity of trade index and its elaborations, the complementarity and country bias indexes are valuable in this respect. Knowledge of the circumstances under which relative resistances as reflected in intensity indexes vary can be used to improve the quality of projections.

Resistances to bilateral trade flows affect the size, commodity composition and gains of foreign trade, and so warrant integration into the pure theory of international trade. This important task has not been attempted in this *Survey*, although a clear view of the nature of *resistances* may assist this development in trade theory.

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