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INTRA-INDUSTRY TRADE
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MEASUREMENT AND DETERMINANTS OF INTRA-INDUSTRY INTERNATIONAL TRADE

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Intra-industry trade (IIT) is the simultaneous export and import by a country of products in the same industry. It is also called "two-way trade" or "trade overlap". Though traditional theories of international trade based upon the principle of comparative advantage (e.g., Ricardo, Heckscher-Ohlin (H-O)) preclude the existence of IIT, the prominence of two-way trade within manufactures trade has been documented by numerous authors.[1]

The growing disparity between traditional inter-industry trade theories and stylized facts concerning industrialized nations' manufactures trade has escalated the development of IIT theories as complements to traditional theories. Recently, Paul Krugman (1979, 1980, 1981), Kelvin Lancaster (1980), Rodney Falvey (1981), Elhanan Helpman (1981), and Wilfred Ethier (1982) developed formal theoretical models to explain the existence of IIT.[2] All of their models have in common elements earlier suggested by Grubel (1967) and Gray (1973): product differentiation and increasing returns to scale.[3]

In contrast to the success of the theoretical models, recent econometric models have consistently failed to explain IIT in terms of these two elements. Two features are prominent in the four econometric studies (to the author's knowledge) : Emilio Pagoulatos and Robert Sorensen (1975), J.M. Finger and Dean DeRosa (1979), Rudolf Loertscher and Frank Wolter (1980), and Richard Caves (1981). First, none of these studies attempted to formally integrate into its empirical model aspects of any of the theoretical studies cited above. Second, all of the empirical models include independent variables in regressions representing the degree of product differentiation and increasing returns.[4] These studies found positive or mixed coefficient estimate signs but statistical insignificance for their product differentiation variables. Worse yet, the studies found negative (opposite of expected) coefficient estimate signs and statistical significance for their increasing returns variables.[5]

Footnote referring to the author appears at the end of this paper.

The primary focus of this study is to establish an integrated framework for theoretical and econometric determinants of IIT and to provide empirical estimates for this integrated model. The theoretical model parallels the recent work cited above by its emphasis on product differentiation and increasing returns. On the demand side, the model is similar to Krugman's; consumers are identical within and across countries and all have a taste for product diversity. However, on the supply side firms face identical, U-shaped average and marginal cost curves found in neo-classical firm theory. IIT is created if no two products are ever perfect substitutes, consumers are identical but all have a taste for diversity, and firms realize initially increasing returns in production.

A major conclusion from my theoretical model is that, in market equilibrium, the degree of increasing returns in an industry (represented by its elasticity of scale) is a positive function of the degree of product differentiation (represented by a function of the elasticity of substitution) in the industry. In a properly specified empirical model based upon this framework, a measure of only one of these variables should be present to explain IIT. Consequently, an independent variable is calculated that measures the degree of increasing returns in the trade between two countries in an industry (and, implicitly, the degree of product differentiation in that trade). Other independent variables are constructed to explain variation in IIT. Although variables measuring effects on IIT of tariff and nontariff trade barriers and transport costs are common, variables measuring the extent of relative factor intensity differences within industries and taste differences across nations have not previously been incorporated into empirical studies.

In Part I, IIT is shown to exist for narrowly defined consumer and nonconsumer products. For a broader and more systematic analysis of the exent of IIT, a new measure of IIT is introduced and used to demonstrate that the usual measure understates the extent of IIT relative to the new measure. The new measure of bilateral IIT (bilateral owing to recent developments in the commodity version of the H-O theorem) simulates actual bilateral disaggregate trade flows to reflect multilateral aggregate trade balance - to insulate IIT indexes from macroeconomic factors. Using usual and new measures, trade overlap is demonstrated to be widespread and to have grown substantially between 1965 and 1976.

In Part II, I discuss theoretical causes for IIT. The large number of tasks and intrinsic complexity of manufactures' production suggest that no two manufacturing firms' products can ever be considered perfect substitutes by consumers. These characteristics also imply that manufactures' production is often characterized by increasing returns to scale over the range of output realized by the typical firm. In the presence of initially increasing returns, countries with similar tastes, technologies, and relative factor endowments can gain from trading in even minutely differentiated products. Furthermore, a greater degree of product diversity increases the degree of trade overlap.

In Part III, an empirical model is formulated based upon the theoretical model and the relative importance of alternative sources of IIT is quantified. Empirical investigation yields that the degree of increasing returns to scale and product differentiation and the extent of government-induced trade liberalization are important in explaining IIT. Second, neither geographic adjacency of countries nor taste differences across countries are found to be prominent sources of IIT. Third, IIT does not appear to be merely an arbitrary consequence of aggregation of products across essentially different industries.

I. THE MEASUREMENT, SCOPE, AND GROWTH OF INTRA-INDUSTRY TRADE

A. The Existence of IIT

A common method for quickly dismissing IIT on empirical grounds is to argue that trade data arbitrarily group into an industry goods that are produced using different relative factor intensities and are not even close substitutes. Nevertheless, IIT persists within even the most narrowly defined trade categories. Table 1 presents data for trade between the United States and both the European Community (EC) and Japan in 10 products at the 8-digit U.S. Standard Industrial Classification (SIC) level. Columns 3 and 4 list U.S. exports to and imports from, respectively, trading partners indicated in Column 2. Even for products as narrowly defined as these, the United States exports and imports sizable amounts of several products with each trading partner.

Column 5 provides an index of the share of trade in each product between each pair of trading partners that is intra-industry in character. The formula used for this index is :

$$(1) \qquad IIT_{ij}^{k} = 1 - [|X_{ij}^{k} - X_{ji}^{k}|/(X_{ij}^{k} + X_{ji}^{k})]$$

where X_{ij}^{k} (X_{ji}^{k}) is the value of the bilateral trade flow, measured cost-insurance-freight, from country i to country j (j to i) in industry k. For example, if the value of the trade flow in

TABLE 1 : Intra-Industry Trade in Various Narrowly Defined Products among the United States, the European Community, and Japan, 1979

(1) Product	(2) US Trading Partner	(3) US Exports to ($)	(4) US Imports from ($)	(5) IIT
Women's, girls' or infants' wool suits SIC 2337XX47 (Exports) 23317C60 (Imports)	EC	47,330	256,239	0.312
	Japan	3,182	760	0.386
Sodium compound, bicarbonate SIC 28122040	EC	178,630	279,034	0.781
	Japan	10,793	1,181	0.197
Stainless steel bars, angles, shapes, rolled flats, and squares SIC 33124040	EC	704,805	781,236	0.949
	Japan	3,603,947	5,429,191	0.798
Metalworking gear tooth grinding and finishing machines SIC 35413040	EC	839,082	2,222,057	0.548
	Japan	830,605	1,005,797	0.905
Metal bending and forming machine tools, over $2500 SIC 35421040	EC	9,257,191	15,265,584	0.755
	Japan	5,708,577	2,804,485	0.659
Offset printing presses, roll-fed type, weighing 3500 lbs. or more SIC 35551040	EC	17,922,423	7,638,747	0.598
	Japan	1,201,060	114,043	0.173

TABLE 1 (ctd.)

Product	U.S. Trading Partner	US Exports to	US Imports from	IIT
Antifriction rollers SIC 35629A40	EC	723,927	5,390,246	0.237
	Japan	7,500	31,173	0.388
Magnetron electronic microwave tubes SIC 36730045	EC	3,439,718	2,126,534	0.764
	Japan	1,698,369	1,366,334	0.892
Thyristors SIC 36749045 (Exports) 36749C40 (Imports)	EC	11,575,465	7,370,046	0.778
	Japan	888,112	1,081,609	0.902
Bowling balls SIC 39495065 (Exports) 39495075 (Imports)	EC	666,402	51,346	0.143
	Japan	373,734	478,401	0.877

Sources : U.S. Bureau of the Census, U.S. Exports : Domestic Merchandise, SIC-Based Products by World Areas, FT610/Annual 1979.
U.S. Bureau of the Census, U.S. Imports : SIC-Based Products, FT210/Annual 1979.

industry k from country i to j is matched by an identically sized flow from j to i, IIT is perfect and the index equals one. If country j exports none of the products in industry k back to country i, the IIT index equals zero. Column 5 indicates that the degree of IIT is high for several of these narrowly defined products.

Commonly cited examples of products showing high IIT include automobiles, cigarettes, sporting goods, and apparel. The frequent citing of IIT in these consumer products suggests a rather simple explanation. Since these products are easily differentiated by brand (e.g., cigarettes) or style (e.g., apparel) with negligible production costs, proliferation of brands or styles makes IIT prominent. Some economists claim that domestic producers tend to specialize in styles of products appealing to the majority of households. As countries achieve high per capita incomes, consumers' tastes diversify - leading to imports of styles appealing to various minority tastes.

However, Table 1 indicates that IIT is as prominent for nonconsumer goods - which compose the bulk of international trade - as for consumer goods, such as women's wool suits and bowling balls.[6] The simple explanation above applies only to consumer goods. Furthermore, the explanation suggests that national tastes differ across industrialized countries. Is this a feasible assumption ? Also, if domestic consumers have tastes for a diversity of products, what prevents the domestic industry's producers from providing the entire range of products to suit these tastes ? Or can every country gain in welfare by producing only some of the products in the industry and exchanging products internationally ? All of these questions are addressed in Parts II and III.

The results in this section generate the questions for the remainder of Part I, a broader and more systematic analysis of the extent and growth of IIT. First, is equation (1) the best measure of IIT? If not, when properly measured, is trade overlap more or less prevalent than previously supposed ? Second, is IIT widespread - both in consumer and nonconsumer manufactures ? Third, is IIT of growing or diminishing importance in international trade ?

B. The Measurement of IIT

Over the years, international economists have measured IIT in various ways. The most common measure, originated by Grubel and Lloyd (1971, 1975), is identical to equation (1), except that it measures multilateral rather than bilateral IIT :

$$(2) \quad A_i^k = 1 - [|X_i^k - M_i^k|/(X_i^k + M_i^k)]$$

where X_i^k (M_i^k) is the value of exports (imports) of country i in industry k.[7] However, the measure in equation (2) is faced with certain conceptual problems not adequately addressed in subsequent studies employing it. First, A_i^k is calculated from actual trade data. Actual trade data, however, tend to incorporate undesirable biases created by macroeconomic disequilibria. Is there a means of "adjusting" trade flows to reflect patterns of specialization but not balance of payments factors ? Second, is a multilateral IIT index appropriate ? Or is IIT more properly measured using a bilateral index ?

Grubel and Lloyd (1971) and Antonio Aquino (1978) established that a measure such as A_i^k would be biased downward owing to (multilateral aggregate) trade imbalances. Although each country's trade imbalance need not have a proportionate effect across industries, on average each industry's trade imbalance would reflect the overall trade imbalance. Assuming that a country's trade imbalance does have a proportionate effect on all industries, Aquino suggested a method for "simulating" multilateral disaggregate trade flows to reflect multilateral aggregate trade balance. Substituting "trade-balanced" multilateral trade flows for actual flows in equation (2) yields a multilateral IIT index insulated from balance of payments influences.[8]

Yet, recent developments in the modern theory of international trade (i.e., H-O theory) leaves work by Aquino short in comparison. Robert Baldwin (1979), Bee-Yan Aw (1980), and others have shown that in a multicountry, multicommodity, two factor, factor price nonequalized world, the commodity version of the H-O theorem need not hold for a country's multilateral trade, but will hold for any pair of countries. The inability of this generalized commodity version of the H-O theorem to hold for multilateral trade suggests that the existence of multilateral IIT is not unexpected; hence, the prominence of multilateral IIT is uninteresting. The holding of this H-O theorem's commodity version for bilateral trade suggests that the presence of bilateral IIT is interesting (because this version of the theorem precludes it). A proof in Appendix A formally demonstrates why multilateral IIT can be expected for this generalized H-O framework.

To the author's knowledge, only three studies have attempted to properly measure IIT, using a bilateral index. Gray (1979) and Larry Willmore (1979) use a bilateral index similar to equation (1), but do not adjust for trade imbalances. Loertscher and Wolter use a bilateral index like equation (1), but first adjust bilateral trade flows for bilateral trade imbalances. The Loertscher-Wolter (L-W) index is simply a bilateral trade extension of Aquino's adjustment method for multilateral trade. [9]

However, L-W's adjustment method faces conceptual problems. First, like Aquino, L-W adjusts trade flows for manufactures trade imbalances. As David Greenaway and Chris Milner (1981) note "The proposed adjustment of intra-industry trade indices (by Aquino and L-W), indicated above, presume both 'disequilibrium' (arbitrarily defined) and forces (relative price, income and/or monetary changes) which will induce adjustments in these particular autonomous transactions and therefore in the structure of international exchanges" (p. 757). Yet, there is no *a priori* justification for manufactures trade balance to represent equilibrium. Since Ricardo's time, the pure theory of trade has consistently associated a country's external equilibrium with multilateral aggregate trade balance.

Second, unlike Aquino, L-W properly uses a bilateral IIT index. However, L-W justifies balancing disaggregate trade flows bilaterally not on theoretical grounds, but "as the sample consists of bilateral trade flows among the OECD-countries, adjustments were made on the basis of bilateral trade balances" (p. 281). Adapting Aquino's adjustment method to bilateral flows is convenient, but not theoretically appealing.

Consequently, a theoretically appropriate measure of IIT should be constructed from bilateral disaggregate trade flows adjusted to simulate multilateral aggregate trade balance. Adjustment for this requires an iterative computational procedure. However, like the Aquino adjustment, this procedure assumes that the multilateral aggregate trade imbalance affects individual industries proportionately. The index is :

$$(3) \qquad IIT_{ij}^{k**} = 1 - [|X_{ij}^{k**} - X_{ji}^{k**}|/(X_{ij}^{k**} + X_{ji}^{k**})]$$

where

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

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

and

$$X_{i.} = \sum_k \sum_j X_{ij}^k \qquad M_{.i} = \sum_k \sum_j X_{ji}^k$$

$$X_{j.} = \sum_k \sum_i X_{ji}^k \qquad M_{.j} = \sum_k \sum_i X_{ij}^k$$

where X_{ij}^k (X_{ji}^k) is defined earlier and the summation over k is across all industries. Computing X_{ij}^{k**} (X_{ji}^{k**}) iteratively until some convergence criterion is met (in this study, $[(X_{ij}^{k**})_t - (X_{ij}^{k**})_{t-1}]/(X_{ij}^{k**})_{t-1} \leq 0.001$) yields bilateral trade flows for industry k that are simulated to reflect multilateral aggregate trade balance. [10] For example, if a particular bilateral flow is low because the exporter (importer) has a multilateral aggregate trade deficit (surplus), the simulation procedure adjusts the actual flow upward. However, the trade-balanced index in equation (3) can be higher or lower than the index in equation (1). The tendency in reality for countries with bilateral trade deficits (surpluses) also to have multilateral trade deficits (surpluses) suggests that the usual bilateral index will tend to understate the degree of IIT relative to the new measure.

C. The Scope of IIT

Before measuring the extent of IIT, empirical dimensions of an industry must be defined and a sample of trade data selected. Several reasons exist for selecting the 3-digit SITC level as representative of an industry. [11] Though the 2- or 3-digit SITC level is widely accepted, the selection of the 3-digit level facilitates work in Part III. However, the most compelling reason is that, as Grubel and Lloyd (1975) note, "the 3-digit SITC statistics separate commodities into groups most closely corresponding to the concept of an 'industry' used conventionally in economic analysis" (p.52).

As noted earlier, IIT is primarily a characteristic of manufacturing industries. Grubel and Lloyd (1975) estimated from actual trade flows multilateral IIT indexes for 1967 by 3-digit SITC industry, averaged these indexes by each 1-digit SITC industry group, and ranked the index averages. Four of the five highest IIT index averages were for manufacturing industry groups (SITCs 5, 6, 7, 8) ; the fifth was for SITC 9 (commodities, n.e.s.). For manufactures, the average of its four industry groups' 1-digit IIT indexes was 0.57 ; for nonmanufactures (except SITC 9), the average of its five industry groups' 1-digit indexes was 0.33.

However, estimating bilateral IIT indexes from actual and trade-balanced flows for all 3-digit manufacturing industries is far beyond the scope of this study. Fortunately, an industry group exists among the four manufacturing industry groups that is clearly representative, for my purposes, of all manufactures : SITC 7, Machinery and Transport Equipment. Numerous reasons exist for considering SITC 7.

First, the composition of U.S. trade within this industry group (consumer versus nonconsumer products) resembles the composition of U.S. trade for all manufactures. In 1980, consumer and non-consumer goods were 9 (13) percent and 91 (87) percent, respectively, of U.S. exports in SITC 7(in nonmilitary manufactures). In the same year, consumer and nonconsumer goods were 36 (41) percent and 64 (59) percent, respectively, of U.S. imports in SITC 7 (in nonmilitary manufactures).[12] Second, even though SITC 7 is only one of 10 industry groups, it represents a disproportionately large share of both manufactures trade and aggregate trade. For all OECD countries in 1979, trade in this industry group represented 45 percent of all OECD manufactures trade and 33 percent of all OECD aggregate trade.[13] Third, the degree of IIT in SITC 7 seems to be more representative of the degree of trade overlap in all manufactures than any of the other three industry groups composing manufactures - chemicals (SITC 5), manufactured goods classified chiefly by material (SITC 6), and miscellaneous manufactured articles (SITC 8). As noted above, Grubel and Lloyd (1975) found an average IIT index for all manufactures of 0.57. For SITC 7, the average index was 0.59. However, IIT indexes for SITCs 5, 6, and 8 were 0.66, 0.49, and 0.52, respectively. Thus, SITC 7 stands out as the industry group most representative of all manufactures.

Indexes of bilateral IIT were calculated for each possible pairing of countries among 14 major industrialized countries.[14] To demonstrate the contrast in measurement, indexes were calculated using both actual and (multilateral aggregate) trade-balanced trade flows for 1976 for each industry in SITC 7. Equation (1) was used for actual flows, equation (3) for trade-balanced flows. To consolidate results, a simple average was computed of each country's 13 bilateral IIT indexes with its trading partners; averaged indexes for the traditional "Big Seven" industrialized countries are provided in Table 2. The top number in each entry is the index average calculated from actual flows; the parenthetical number is that calculated from trade-balanced flows.

Several points are noteworthy. First, IIT is widespread ; it shows up prominently across countries and industries represented in Table 2. Second, IIT appears to be as important as inter-industry trade. Over one-half of the entries (either actual or trade-balanced flows) exceed 0.50, implying that trade between pairs of countries for these industries is more intra-industry than inter-industry in character. Third, a strong tendency exists for IIT indexes calculated from trade-balanced flows to exceed those calculated from actual flows ; almost two-thirds of trade-balanced indexes are higher than corresponding indexes using actual flows. Furthermore, the difference is sometimes quite large. For instance, in SITC 724, Japan's IIT index using trade-balanced flows is 88 percent higher than the index using actual flows. Thus, while Table 1 showed that IIT does not disappear for even the most narrowly defined industries, Table 2 reveals not only that bilateral trade overlap is widespread but that it is much more intense than the usual measure suggests.

D. The Growth of IIT

Analyzing the growth of trade overlap permits examining its importance while holding constant the level of industry aggregation. Thus, the analysis is insulated from problems associated with "arbitrary aggregation" of essentially different industries. IIT index averages for the same seven countries were calculated for 1965 in the same manner as for 1976 in Table 2. For each country in each industry, the percentage change in the index average over the period 1965 to 1976 was calculated.

Table 3 presents the results. The top number in each entry is the percentage change calculated from actual flows, the parenthetical number from trade-balanced flows. The results in Table 3 clearly suggest widespread growth in IIT across industries and countries, as 75 percent of the entries are positive. The prevalence of growth in IIT across industries and countries suggests that trade among industrialized countries in manufactures is rapidly becoming more intra-industry and, consequently, less inter-industry in character. Thus, it seems important to understand the causes of IIT, which the remaining two parts of this study address.

II. CAUSES OF INTRA-INDUSTRY TRADE

Causes of IIT usually are separated into two general categories: trade in "functionally homogeneous" products and trade in differentiated products. Functionally homogeneous describes products in an industry that are perfect substitutes in consumption and are produced using identical technologies and relative factor

TABLE 2 : Actual and "Trade-Balanced" Intra-Industry Trade Indexes in SITC 7, Machinery and Transport Equipment, among Selected OECD Countries for 1976

SITC	Canada	United States	Japan	France	West Germany	Italy	United Kingdom
711 Power generating machinery, other than electric	.44 (.40)	.52 (.55)	.45 (.51)	.59 (.59)	.53 (.62)	.65 (.62)	.73 (.67)
712 Agricultural machinery and implements	.44 (.34)	.50 (.51)	.37 (.29)	.65 (.66)	.44 (.50)	.55 (.54)	.52 (.48)
714 Office machines	.58 (.60)	.34 (.42)	.50 (.58)	.66 (.68)	.62 (.66)	.70 (.68)	.67 (.67)
715 Metalworking machinery	.19 (.14)	.58 (.60)	.37 (.52)	.66 (.67)	.38 (.41)	.50 (.53)	.58 (.62)
717 Textile and leather machinery	.11 (.09)	.45 (.43)	.41 (.50)	.53 (.53)	.40 (.42)	.58 (.63)	.59 (.61)
718 Machines for special industries	.24 (.16)	.58 (.62)	.52 (.59)	.68 (.72)	.50 (.56)	.72 (.73)	.52 (.60)
719 Machinery and appliances, not elsewhere classified	.40 (.29)	.63 (.68)	.64 (.63)	.65 (.65)	.56 (.62)	.70 (.74)	.73 (.74)
722 Electric power machinery and switchgear	.43 (.38)	.51 (.57)	.54 (.61)	.63 (.69)	.53 (.63)	.66 (.70)	.65 (.67)
723 Equipment for distributing electricity	.46 (.46)	.54 (.66)	.42 (.55)	.55 (.57)	.59 (.66)	.53 (.55)	.66 (.65)

TABLE 2 (ctd.)

SITC	Canada	United States	Japan	France	West Germany	Italy	United Kingdom
724 Telecommunications apparatus	.44 (.35)	.39 (.50)	.08 (.15)	.63 (.61)	.47 (.55)	.57 (.61)	.69 (.69)
725 Domestic electrical equipment	.18 (.13)	.41 (.41)	.64 (.54)	.66 (.64)	.41 (.44)	.25 (.25)	.63 (.66)
726 Electric apparatus for medical purposes	.38 (.28)	.65 (.64)	.53 (.45)	.56 (.56)	.55 (.59)	.56 (.53)	.60 (.59)
729 Other electric machinery and apparatus	.70 (.60)	.45 (.56)	.53 (.60)	.72 (.73)	.62 (.69)	.60 (.63)	.69 (.73)
731 Railway vehicles	.16 (.13)	.25 (.25)	.24 (.25)	.42 (.43)	.43 (.45)	.30 (.28)	.44 (.47)
732 Road motor vehicles	.36 (.38)	.38 (.36)	.13 (.18)	.40 (.40)	.37 (.42)	.36 (.39)	.40 (.40)
733 Road vehicles other than motor vehicles	.07 (.05)	.35 (.31)	.13 (.16)	.42 (.43)	.36 (.42)	.40 (.44)	.32 (.33)
734 Aircraft	.36 (.42)	.20 (.22)	.22 (.19)	.45 (.49)	.47 (.50)	.42 (.43)	.53 (.47)
735 Ships and boats	.49 (.43)	.38 (.40)	.39 (.46)	.39 (.43)	.53 (.56)	.26 (.27)	.44 (.40)

Source : OECD Trade Series C - Trade by Commodities, 1976.

Note : The top number in each entry is the index average calculated from actual trade flows ; the parenthetical number is that calculated from trade-balanced trade flows.

TABLE 3 : Percentage Change in Actual and "Trade-Balanced" Intra-Industry Trade Indexes in SITC 7 among Selected OECD Countries from 1965 to 1976

SITC	Canada	United States	Japan	France	West Germany	Italy	United Kingdom
711 Power generating machinery, other than electric	49.4 (37.4)	70.0 (56.8)	30.7 (88.5)	3.6 (4.4)	14.2 (25.7)	15.4 (19.8)	42.8 (40.7)
712 Agricultural machinery and implements	52.6 (44.4)	8.4 (2.0)	61.9 (66.1)	20.5 (13.3)	-5.7 (1.7)	13.8 (14.6)	52.9 (53.0)
714 Office machines	1.2 (10.3)	-34.4 (-28.0)	82.7 (161.5)	13.8 (12.7)	5.0 (5.8)	59.5 (52.9)	14.9 (14.9)
715 Metalworking machinery	71.9 (77.8)	33.2 (23.2)	12.7 (83.2)	17.0 (20.8)	-0.7 (8.4)	11.6 (10.4)	14.3 (24.9)
717 Textile and leather machinery	-53.7 (-62.8)	-13.2 (-20.4)	8.5 (24.8)	-10.9 (-7.7)	-3.3 (5.6)	25.1 (32.1)	-5.9 (2.7)
718 Machines for special industries	1.8 (-19.2)	44.6 (20.8)	67.7 (135.7)	14.6 (17.3)	22.9 (24.3)	40.1 (27.0)	8.3 (20.7)
719 Machinery and appliances, not elsewhere classified	-4.3 (-15.7)	37.9 (19.8)	46.7 (67.6)	0.3 (-3.2)	5.6 (10.2)	3.6 (7.6)	22.5 (25.4)
722 Electric power machinery and switchgear	23.3 (32.9)	13.2 (25.8)	17.3 (57.8)	-5.2 (9.0)	11.8 (20.4)	7.2 (23.8)	5.5 (15.2)
723 Equipment for distributing electricity	13.3 (11.0)	113.1 (103.8)	18.7 (43.8)	-1.8 (-0.7)	9.1 (5.8)	-13.3 (-12.5)	55.3 (61.7)
724 Telecommunications aaparatus	15.4 (2.5)	-7.5 (-0.1)	-67.6 (-55.6)	6.2 (-1.1)	-4.3 (8.8)	19.0 (18.3)	38.4 (30.9)

TABLE 3 (ctd.)

	Canada	United States	Japan	France	West Germany	Italy	United Kingdom
725 Domestic electrical equipment	-29.4 (-40.1)	-11.9 (-9.2)	52.1 (29.6)	17.7 (19.5)	16.8 (27.7)	-2.9 (-15.3)	23.7 (38.7)
726 Electrical apparatus for medical purposes	6.6 (-14.6)	46.6 (46.9)	39.6 (11.2)	-7.1 (-6.7)	57.8 (59.8)	-11.5 (-12.8)	29.5 (31.3)
729 Other electric machinery and apparatus	27.7 (19.4)	-7.3 (-8.7)	-21.5 (-7.8)	10.3 (20.6)	13.6 (20.0)	-7.6 (-6.4)	16.0 (29.1)
731 Railway vehicles	197.3 (141.2)	21.0 (23.8)	68.4 (70.9)	3.6 (-0.1)	31.7 (34.3)	58.7 (72.2)	59.6 (89.6)
732 Road motor vehicles	47.7 (70.5)	3.1 (12.6)	-58.7 (-48.0)	8.9 (5.9)	32.3 (43.8)	39.4 (45.5)	17.7 (34.3)
733 Road vehicles other than motor vehicles	1.2 (-31.3)	17.1 (6.6)	29.4 (130.3)	10.4 (6.8)	-8.0 (2.8)	38.3 (33.7)	26.6 (32.0)
734 Aircraft	99.1 (126.7)	31.1 (45.0)	-5.7 (-9.4)	54.3 (60.4)	-7.9 (2.6)	-4.7 (3.8)	-3.3 (-11.9)
735 Ships and boats	141.6 (101.1)	-15.8 (-18.4)	141.9 (192.9)	-12.5 (-4.0)	-4.7 (-3.5)	-33.2 (-31.6)	25.2 (3.3)

Source : OECD Trade Series C - Trade by Commodities, 1965, 1976.

Note : The top number in each entry is the growth rate calculated from actual trade flows ; the parenthetical number is that calculated from trade-balanced trade flows.

intensities, but are differentiated by time of production, location of production, or government interference in the market. Differentiated products compose an industry where products are close, yet imperfect, substitutes in consumption, but are produced using identical technologies and relative factor intensities.

However, trade overlap in functionally homogeneous goods is consistent with traditional comparative cost theories when the latter are modified to allow for imperfections such as the presence of tariff and nontariff barriers to trade, variation across countries in the timing and severity of business cycles, and nonzero transportation, selling, information, packaging, and storage costs (henceforth, called transport costs). Consequently, recent theoretical models of IIT cited earlier emphasize the existence of product differentiation and initially increasing returns to larger firm size for gains from trade to exist among countries with identical tastes, technologies, and relative factor endowments.

Section A presents an open economy model of a single industry that is representative of the typical manufacturing industry. The demand side parallels recent work by Paul Krugman. Two key elements in demand are that no two manufacturing firms' products are perfect substitutes and consumers have identical tastes, yet each has a taste for diversity. However, on the supply side, manufacturing firms face typical, neoclassical, short- and long-run cost curves. Given certain assumptions, IIT is demonstrated to exist between two countries showing identical tastes, technologies, and relative factor endowments.

Section B extends the theoretical model by first establishing that, in equilibrium, the degree of increasing returns (measured by the elasticity of scale) of the typical firm is a positive function of the degree of product differentiation (measured by a function of the elasticity of substitution) in the industry. Second, the degree of IIT between two countries in an industry is demonstrated to be a positive function of the degree of product differentiation and, implicitly, increasing returns. Previous theoretical work has established only the need for the existence of product differentiation and increasing returns to explain the existence of IIT. My results provide the necessary link to the empirical literature to establish why a higher degree of IIT is correlated with greater product diversity and a higher elasticity of scale.

A. The Model

The model assumes the existence of many products and firms in a single, worldwide industry. Two countries are assumed to have

differing absolute endowments of the single factor, labor. Consumers are assumed to have identical tastes within and across countries to ensure that IIT is not caused by taste differences. All firms within and across countries have identical neoclassical cost curves to ensure that IIT is not caused by technology differences. The assumption of a single homogeneous factor of production ensures that trade is not caused by relative factor endowment differences. The market structure is Chamberlinian monopolistic competition. Assume zero transport costs and no artificial trade barriers; foreign country variables are denoted by an asterisk. The prominence of similar models in the literature suggests it is unnecessary to first develop the closed economy analogue to this framework.

Similar to Krugman's models, each consumer, regardless of country, shares the common constant elasticity of substitution (CES) utility function :

$$(4) \qquad U = \Big[\sum_{n=1}^{N+N^*} a_n c_n^{\theta} \Big]^{1/\theta}$$

where N (N^*) is the number of products in the industry made domestically (abroad), a_n is the relative importance in utility of product n, c_n is the amount of product n consumed by the representative household, and $\theta = (\rho-1)/\rho$ where ρ is the (constant) elasticity of substitution.[15] All products are close, but imperfect, substitutes; hence, $\theta < 1$. To ensure a taste for diversity, all products are assumed to enter utility symmetrically; hence, $a_n = a$ for all n.

Assume that the home (foreign) country is comprised of L (L^*) laborers who consume all output of the industry and that $L \neq L^*$. Assume each individual is constrained by an identical budget constraint :

$$(5) \qquad \sum_{n=1}^{N+N^*} p_n c_n = y$$

where p_n is the price of product n and y is the representative consumer's budget for this industry. Because consumers across countries are identical, total output of each product (X_n) is consumed proportionately across consumers :

$$(6) \qquad X_n = (L + L^*) c_n \quad \text{for all n.}$$

Maximizing equation (4) subject to equation (5) yields demand curves for each individual in each product. For the representative consumer for product q:

$$(7) \qquad p_q = \lambda^{-1} \left[\sum_{n=1}^{N+N^*} a_n c_n^{\Theta} \right]^{\frac{1}{\Theta}-1} a_q c_q^{\Theta-1}$$

where λ is the marginal utility of income (i.e.,LaGrangean multiplier). Equations (6) and (7) suggest the market demand curve facing producer q :

$$(8) \qquad p_q = \lambda^{-1} \left[\sum_{n=1}^{N+N^*} a_n X_n^{\Theta} \right]^{\frac{1}{\Theta}-1} a_q X_q^{\Theta-1}$$

which implies a price elasticity of demand facing firm q (one of many firms in the industry) equal to :

$$(9) \qquad \varepsilon_q = 1/(1 - \Theta)$$

in the limit $(N + N^* \to \infty)$.

On the supply side, all firms - regardless of country - are assumed to have an identical neoclassical cost function, C(X), representable by the general form :

$$(10) \quad C(X_q) = \delta_0 + \delta_1 X_q + \delta_2 X_q^2 + \delta_3 X_q^3$$

With parameter restrictions,

$$\delta_0, \delta_1, \delta_3 > 0 \qquad \delta_2 < 0 \qquad (\delta_2)^2 < 3\delta_1 \delta_3$$

imposed, the cost function suggests typical U-shapes for its long-run average cost (AC) and marginal cost (MC) curves.

The downward sloping portion of the AC curve implies the presence of increasing returns internal to the firm - up to a point. The usual sources of these economies (and ultimately diseconomies) are noted in F.M. Scherer (1970). It will turn out that the representative firm chooses a level of output in the region of increasing returns. It will be useful to note that the degree of increasing returns at a particular level of output can be measured by the "production function (PF) coefficient"(β) where:

$$(11) \quad X_q = \zeta\, \ell_q^{1+\beta}$$

where ℓ_q is the number of laborers needed to produce X_q and ζ is a constant. It can be shown that :

$$(12) \quad 1 + \beta(X_q) = AC(X_q)/MC(X_q)$$

where 1 + β, a decreasing function of X, is the elasticity of scale.

With many firms in the industry, L (L^*) laborers in the home (foreign) country are distributed across N (N^*) differentiated products :

$$(13) \quad L = \sum_{n=1}^{N} \ell_n \qquad L^* = \sum_{n=1}^{N^*} \ell_n$$

The theory of monopolistic competition is characterized by two long-run equilibrium conditions. Profit maximization by each firm suggests maximizing :

$$(14) \quad \pi_q = p_q X_q - C(X_q)$$

subject to market demand equation (8) and cost function (10). This yields the first equilibrium condition :

$$(15) \quad p_q = \Theta^{-1} MC(X_q)$$

The second condition is that firms enter the (barrier-free) market until economic profits are driven to zero :

$$(16) \quad \pi_q = p_q X_q - C(X_q) = 0$$

This second equilibrium condition can be rewritten as :

$$(17) \quad p_q = AC(X_q)$$

Long-run equilibrium output and price choices by the q^{th} firm are found by solving equations (15) and (17) for $\overline{X}$ and $\overline{p}$. The equilibrium output for the representative firm is :

$$(18)\quad AC(\overline{X})/MC(\overline{X}) = \theta^{-1}$$

As noted earlier, imperfect product substitution ensures $\theta < 1$. Hence, the representative firm supplies output in the downward sloping portion of the AC curve. Since cost functions are identical across firms, output and price are identical across firms.

The stability of the equilibrium is ensured by an appropriate restriction on parameter values for δ_0, δ_2, and δ_3 (i.e., $\delta_2 + 3\delta_3 X > 0 > \delta_2 + 2\delta_3 X - \delta_0 X^{-2}$). Equilibrium output is just short of the minimum average-cost output, where MC is rising (i.e., $C''(X) = \delta_2 + 3\delta_3 X > 0$) and AC is still falling (i.e., $AC'(X) = \delta_2 + 2\delta_3 X - \delta_0 X^{-2} < 0$). The number of products made by each country can be solved for since all products are made in the same volume using the same number of laborers (i.e., $L = N\ell$, $L^* = N^*\ell$):

$$(19)\quad N = L/C(\overline{X}) \qquad N^* = L^*/C(\overline{X})$$

where the wage rate is assumed equal to unity.

Finally, note that the number of types of products made in each country is proportional to the absolute factor endowment. Since all goods have the same price and are viewed symmetrically in utility, home country exports (foreign imports) are proportional to the share of all goods produced by the home country :

$$(20)\quad EX = [N/(N + N^*)]\, Y^*$$

where EX is the value of home country exports and Y^* is the foreign country's expenditures for this industry. Home country imports are :

$$(21)\quad IM = [N^*/(N + N^*)]\, Y$$

where IM is the value of home country imports and Y is the home country's expenditures for this industry. As is common in this class of models, IIT exists.

B. Relationships among the Degrees of Increasing Returns, Product Differentiation, and Intra-Industry Trade

First, since θ is a positive function of the elasticity of substitution, then $\gamma = \theta^{-1}$ is an index of the degree of product differentiation in the industry. Equilibrium output $(\overline{X})$ must satisfy equation (18) and, consequently, equation (12). Hence, in long-run equilibrium, the degree of increasing returns, measured by the PF coefficient, is a positive function of the degree of product differentiation in the industry:

$$(22)\quad 1 + \beta(\overline{X}) = \theta^{-1} = \gamma$$

Consequently, in a regression analysis based upon this theoretical framework, only a measure of one of these variables should be included as an explanatory variable of IIT.

Second, this model, like others in its class, only suggests that IIT exists in the presence of initially increasing returns and product differentiation ; the model does not indicate the positive relationship among the degree of IIT and degree of product differentiation - necessary for an empirical analysis. This latter relationship is now shown.

In reality, an industry is not comprised of symmetric products ; it is comprised of groups of products in varying degrees of product diversity. For example, between two countries (i and j) in industry k, the degree of product diversity (γ^k_{ij}) can be given by :

$$(23)\quad \gamma^k_{ij} = \alpha^{k1}_{ij}\,\gamma^{k1} + (1 - \alpha^{k1}_{ij})\,\gamma^{k2}$$

where α^{k1}_{ij} $(1 - \alpha^{k1}_{ij})$ is the share of trade between countries i and j in product class 1 (2) of industry k (i.e., $\alpha^{k1}_{ij} = [(X^{k1}_{ij} + X^{k1}_{ji})/(X^k_{ij} + X^k_{ji})]$) and γ^{k1} (γ^{k2}) is the degree of product differentiation or increasing returns in product class 1 (2), common to all countries. Let the two product classes be characterized by $\gamma^{k1} > 1$ (i.e., imperfect product substitution) and $\gamma^{k2} = 1$ (i.e., perfect product substitution).

Furthermore, the degree of IIT between countries i and j in industry k can be expressed in terms of product classes :

$$(24)\quad IIT^{k}_{ij} = 1 - [\alpha^{k1}_{ij}\frac{|X^{k1}_{ij} - X^{k1}_{ji}|}{(X^{k1}_{ij} + X^{k1}_{ji})} + (1 - \alpha^{k1}_{ij})\frac{|X^{k2}_{ij} - X^{k2}_{ji}|}{(X^{k2}_{ij} + X^{k2}_{ji})}]$$

where X^{km}_{ij} is the trade flow from country i to j in product class m of industry k. For example, if α^{k1}_{ij} equals 1 (0), the IIT index is given by the degree of IIT in product class 1 (2).

For the given values of γ^{k1} and γ^{k2}, the degree of product differentiation in the trade between countries i and j in industry k can rise only if α^{k1}_{ij} rises. With some algebraic manipulation, it can be shown that IIT^{k}_{ij} will rise when α^{k1}_{ij} (and, hence, γ^{k}_{ij}) rises, if and only if :

$$(25)\quad 1 - [|X^{k1}_{ij} - X^{k1}_{ji}|/(X^{k1}_{ij} + X^{k1}_{ji})] > 1 - [|X^{k2}_{ij} - X^{k2}_{ji}|/(X^{k2}_{ij} + X^{k2}_{ji})]$$

However, by assumption, goods in product class 2 are perfect substitutes and, consequently, trade in product class 2 must be one-way. Thus, the RHS of equation (25) is zero. Yet, the presence of imperfect substitution in product class 1, given the model in Section A, suggests that trade overlap exists in this product class. Hence, the LHS of equation (25) is positive. Consequently, the greater the degree of product differentiation and increasing returns implicit in the trade between two countries in an industry, the greater the degree of IIT.

III. EMPIRICAL DETERMINANTS OF INTRA-INDUSTRY TRADE

In reality, of course, the world is not as symmetric or barrier-free as the model in Part II suggests. The elasticity of substitution is probably not constant across products. Relative preferences across products are not likely to be symmetric (i.e., $a_n \neq a$). Tastes and technologies are not likely to be identical across countries. Consequently, an econometric model explaining IIT should also include measures of factors influencing trade overlap other than imperfect product substitution and initially increasing returns.

In the first section, independent variables are described that potentially explain IIT in differentiated products, including measures of increasing returns and tariff/nontariff protection. In Section B, causes of IIT in functionally homogeneous products are discussed. Cyclical demand influences and nonzero transport costs are addressed as determinants of IIT. In the third section, potential effects on IIT of actual taste differences across nations and actual differences in the relative factor intensities used to manufacture products in the same "industry" are discussed. The last section summarizes the results of the regression analysis explaining IIT. The statistical explanation of IIT is shown to be dominated by the degree of increasing returns and product differentiation and the extent of government-induced trade liberalization. Relatively little IIT is caused by "border trade" and taste differences across countries. Furthermore, relative factor intensity differences increase the degree of inter- rather than intra-industry trade, as expected.

A. Determinants of IIT in Differentiated Products

Previous econometric studies of IIT - Pagoulatos and Sorenson (P-S), Finger and DeRosa (F-D), Loertscher and Wolter (L-W), and Caves - focused on measures of increasing returns and product differentiation as key determinants of IIT. With the exception of L-W, all were cross-industry regression analyses. Though L-W was a cross-industry and cross-country approach, industry-specific variables (including scale economies and product differentiation) were limited to the cross-industry aspect of the analysis. In general, these studies found positive or mixed coefficient estimate signs but statistical insignificance for their product differentiation variables. Furthermore, F-D, L-W, and Caves generally found negative coefficient estimate signs and statistical significance for their increasing returns variables; P-S did not include an increasing returns variable.

The econometric specification of the increasing returns and product differentiation variables in this study is unique in two ways. First, my theoretical model suggests that, in market equilibrium, the degree of increasing returns in the industry is a positive function of the degree of product differentiation. Since these two factors will vary together perfectly, a proper econometric specification can include only one of these variables. Since a more accurate measurement of the degree of increasing returns is possible, this variable is included explicitly.

Second, my index of scale economies is measured across countries for a specific industry, rather than across industries. Cross-country measurement of scale economies for a specific industry insulates the index from undesirable biases, such as variation in market structure and product characteristics across industries. For example, the ease with which a product is transported influences the extent to which potential increasing returns are fully exploited. If transport costs are a very large percentage of a firm's costs, production may be spread over a wide geographic area and increasing returns may not be efficiently exploited. Furthermore, artificial barriers may exist that cause an industry to be dominated by a few oligopolistic firms. With few firms, industry production may be geographically concentrated suggesting a low degree of IIT (in the limit, a single firm is exporter and no IIT exists). However, a cross-country index of scale economies for a specific industry measures the degree of increasing returns (and, implicitly, product diversity) for a given market structure and unchanging product characteristics.

The construction of this index has two parts. First, the production function coefficient, β in equation (11), is estimated for each 3-digit product class in each 2-digit industry in SITC 7 using 1977 U.S. Census of Manufactures data. Details of the estimation and results are presented in Appendix B. Second, each 3-digit U.S. production function coefficient is weighted by the share of trade between countries i and j in that 3-digit product class out of total trade between i and j in 2-digit SITC industry k. Formally, the increasing returns/product differentiation variable (IR) is :

$$(26) \quad IR_{ij}^{k} = \sum_{m=1}^{M} \alpha_{ij}^{km} \; PF^{km}$$

where α_{ij}^{km} is the share of 1976 trade between countries i and j in product class m of industry k (as used earlier) and PF^{km} is the U.S. production function coefficient for product class m in industry k. Data constraints in the Census of Manufactures limit disaggregation in the regression analysis to the 2-digit SITC level. By using only U.S. estimates of production function coefficients, a restriction of identical technologies is imposed across countries. Given the theoretical framework, a higher value for this variable implies two countries are trading more widely differentiated products at a higher elasticity of scale. Hence, the degree of IIT should be higher.

Furthermore, note that variation in this variable across countries for each k industry will be low. Though statistically unappealing, the low variation is theoretically appealing because the variation can be associated with a particular, identifiable source. The cross-country index can filter out biases created by commodity

transportability differences and market structure differences across industries.

The degree of IIT in differentiated products can also be affected by the extent of government market interference. Trade liberalization generally encourages both inter- and intra-industry trade. However, there is a reason to believe that such liberalization will stimulate IIT more than inter-industry trade.

Traditionally, tariff reductions by a country in relatively labor-intensive industries are viewed unfavorably by those industries' laborers. The Stolper-Samuelson corollary suggests that a tariff cut will reduce both nominal and real wages of labor. However, domestic goods are not as easily displaced by imports following mutual trade liberalization when products are imperfect substitutes. Domestic price reductions of imported products could increase the whole industry's share in consumer expenditures; mutual tariff reductions offer both countries' consumers wider product choice.[16] Thus, mutual trade liberalization will likely occur where product diversity and increasing returns are prominent, so as to reduce the inevitable costs of factor reallocation. Early evidence of this followed formation 25 years ago of the European Community (EC). Bela Balassa (1975) estimated an average rise in the degree of IIT of 30% across member countries from 1958 to 1970.

In this study, the influence on IIT of effective tariff and nontariff protection is captured by nominal tariff rates. High correlation coefficients between industries' nominal tariff rates and their effective tariff and nontariff rates suggest that the former are apt proxies for the latter.[17] The GATT's Basic Documentation for Tariff Study provides post-Kennedy Round nominal tariff data for 14 major industrialized countries (the reason for the countries chosen for this study) disaggregated by product category.[18] In SITC 7, GATT product categories correspond to 2-digit SITC industries (SITCs 71, 72, 73). Like the increasing returns variable, tariff data constraints limit disaggregation in the regression analysis to the 2-digit SITC level. For every pair of countries, the tariff variable is the simple average of the two countries' nominal tariff rates in industry k.[19] The presence of relevant preferential trading arrangements is noted by setting the tariff variable at zero when both countries are members of the EC, both are members of the European Free Trade Association (EFTA), or one is in the EC and other in EFTA. A lower degree of protection is expected to increase the degree of IIT.

B. Determinants of IIT in Functionally Homogeneous Products

Traditional static trade theories usually assume the absence of governmental distortions in markets, the absence of transport costs, and the production and consumption of all products at a single point in time. A departure from each of these assumptions can create IIT in otherwise homogeneous products.

The extent and complexity of government market interference in the form of tariffs, quotas, subsidies, etc. have been cited as causes of two-way trade in homogeneous products, as well. Grubel and Lloyd (1975) note that tariffs and subsidies "at one point made it profitable for Indian firms to import, unload, reload, and export the identical commodity on the identical ship" (p.83). However, this type of IIT is expected to be quantitatively minor and to be offset entirely by the effect of trade liberalization on increasing trade overlap in the industry's differentiated products.

In traditional trade theories, nations have no physical or geographic dimensions; that is, transport costs are assumed to be zero. In reality, nations possess physical boundaries that suggest marketing areas may cross national borders. Because unit transport costs may be a substantial portion of unit price, a country may produce and export a commodity on its west coast while importing the identical commodity on its east coast. IIT of this nature is termed "border trade".

To determine whether border trade is a quantitatively prominent source of IIT, two independent variables are included in regressions. Distance (in nautical miles) between economic centers of trading partners has been found to be a good index of transport costs and is expected to have a negative impact on IIT. [20] To account for special economic relations that develop between neighboring countries owing to cultural, historical, and/or language ties, a dummy variable representing geographic adjacency is also included. Because the dummy assumes a value of one when trading partners share a land border and zero otherwise, the variable is expected to have a positive influence on IIT.

Just as traditional trade theories ignore transport costs, these theories ignore changes in production and consumption patterns over time. In reality, differences across countries in the timing and severity of business cycles may give rise to IIT in homogeneous products that would not exist otherwise. To suppress the influence of such cyclical demand conditions, the dependent variable is calculated from annual trade data averaged over three years (1975-1977).

Another source of IIT in homogeneous commodities is "reexport trade". This refers to the import of goods that are reexported after some minor processing, such as blending, packaging, sorting, etc. This trade is fairly insignificant ; for example, U.S. reexports in 1980 accounted for only 1.9 percent of all exports. Consequently, such trade is ignored.

C. Other Determinants of IIT

The conceptual model of causes of IIT in differentiated products relies upon several restrictive assumptions. This section discusses two independent variables to be included in the regression analysis in the event that two of these assumptions fail to hold.

First, the theoretical model assumes that an industry is comprised of firms using identical relative factor intensities in production. In reality, differences in relative factor intensities among groups of products in an industry exist and these differences can influence the degree of IIT. Recall that the indexes of IIT measure the share of trade between two countries that "overlaps", i.e.,that is not inter-industry in character. If trade between two countries in an "industry" is dominated by product groups using widely different relative factor intensities, the countries are effectively exchanging products of different industries. Thus, trade is more inter-industry in character, and the IIT index should decline.

The independent variable in the regressions to capture this effect measures the extent to which trade between two countries in an "industry" is dominated by product classes of widely varying capital-labor, or K-L, ratios (human capital omitted owing to an absence of comprehensive disaggregate data). Relative factor intensity differences in an industry are measured by squared deviations of U.S. K-L ratios for 3-digit SITCs from the average K-L ratio for each 2-digit industry. The larger the share of an industry's trade between two countries in product classes with widely varying relative factor intensities, the larger the implicit exchange of factors (or H-O trade), and the smaller the expected degree of trade overlap. [21]

Second, the theoretical model assumes identical tastes across industrialized nations. In reality, tastes among these nations are similar, but not identical. [22] Minute taste differences can create trade. Such differences are representable by an explanatory variable that measures the extent to which trade between a pair of countries in an industry is dominated by product groups possessing disproportionately large or small relative importance for the respective countries.

In constructing this variable, a measure is derived of the (price-weighted) relative importance in each importing country's welfare of each product class of each exporter. Squared deviations of this measure from the mean for all importers indicates the dissimilarity of each importer's tastes for an exporter's product from the norm for all importers. The larger the share of a 2-digit industry's trade between two countries in product classes possessing disproportionately large or small relative importance in the respective countries' welfares, the greater are implicit taste differences in the two countries' trade. Appendix C describes formally this variable's construction. Some IIT - though not necessarily a quantitatively significant amount - is expected to be created by differing tastes across countries.

D. Estimation Methodology and Results

The various sources of IIT described are combined in a multiple regression analysis to determine if these proposed behavioral causes can be empirically verified. Furthermore, the analysis should determine quantitatively the relative explanatory power of these competing sources.

Initially, three regressions are estimated. The dependent variable in all regressions is a logit transformation of the IIT index:

$$(27) \quad LIIT^k_{ij} = \ln[IIT^k_{ij}/(1-IIT^k_{ij})]$$

where IIT^k_{ij} is an index of trade overlap between countries i and j in 2-digit industry k. A pure index as the dependent variable yields biased coefficient estimates owing to truncations of the continuous distribution at 0 and 1. The logit of the index will yield unbiased coefficient estimates in regressions. [23] However, in each of the first three regressions, the IIT index is calculated a different way. All independent variables in regressions (except dummy variables) are expressed in natural logarithms so that coefficient estimates are elasticities. Independent variables are the same across regressions except for whether actual or trade-balanced trade flows are used in their construction.

Furthermore, all regressions are estimated by weighted least squares. Though the logit of the IIT index, LIIT, yields unbiased estimates, it can be shown that ordinary least squares (OLS) implies $E(u^k_{ij}) = 0$ but $Var(u^k_{ij}) = 1/[IIT^k_{ij}(1 - IIT^k_{ij})]$, where

u^k_{ij} is the error term in an OLS regression of LIIT on a vector of independent variables (assuming IIT^k_{ij} is drawn from a sample of one). To avoid heteroskedasticity, dependent and independent variables are first weighted by $\sqrt{IIT^k_{ij}(1 - IIT^k_{ij})}$, then least squares is performed. [24] In Tables 4 and 5, "quasi-constant" indicates that the constant term is replaced by $\sqrt{IIT^k_{ij}(1-IIT^k_{ij})}$ as a consequence of the transformation.

In the first regression, the IIT index is calculated as in equation (1) using actual bilateral trade flows among the same 14 OECD countries used earlier for each 2-digit industry (71, 72, 73) in SITC 7 (i.e., 91 indexes for each industry). Due to data constraints previously discussed, the 2-digit SITC level is considered an industry. To expand the power of each of the first three regressions, cross-country observations are "pooled" across all three industries. However, dummy variables are introduced to account for differences across industries in their average levels of IIT owing to innate differences in industry characteristics (e.g., transportability of output, market structure,etc.). Variable SITC 71 (SITC 73) assumes a value of one when an observation is for SITC 71 (SITC 73) and zero otherwise.

In the second regression, the IIT index is calculated from equation (3), employing bilateral trade data simulated to reflect multilateral aggregate trade balance (TB - IIT). In all other respects, the dependent variable is the same as in the first specification. When appropriate, independent variables are constructed using trade-balanced trade flows.

In the third regression, the IIT index (using trade-balanced flows) is calculated for each 2-digit industry using an average of 3-digit SITC indexes of IIT - to show that regression results are not spuriously created by "arbitrary product aggregation" (3-digit average, TB - IIT). The dependent variable is the weighted logit of the following index :

$$(28) \quad AIIT^{k*}_{ij} = 1 - \frac{1}{M}\sum_{m=1}^{M}[|X^{km*}_{ij} - X^{km*}_{ji}|/(X^{km*}_{ij} + X^{km*}_{ji})]$$

where X^{km*}_{ij} (X^{km*}_{ji}) is the value of the trade-balanced flow from country i to j (j to i) in product class m of industry k. Due to resource constraints, this alternative index is calculated

TABLE 4 : Regression Results Using Alternative IIT Indexes as Dependent Variable

Variables	Expected Coefficient Estimate Signs	Regressions (1) 2-digit IIT	(2) 2-digit TB - IIT	(3) 3-Digit Averages TB - IIT
Increasing Returns/Product Differentiation	+	0.538^{c} (2.468)	0.485^{c} (2.367)	0.695^{c} (4.327)
Tariff	-	-0.003 (0.094)	-0.098^{c} (2.921)	-0.043^{b} (2.057)
Distance	-	-0.435^{c} (3.565)	-0.093 (0.787)	-0.133^{b} (1.809)
Adjacency	+	-0.386^{b} (1.850)	-0.083 (0.402)	0.157 (1.237)
Factor Intensity Differences	-	-0.679^{c} (3.210)	-0.528^{c} (2.501)	-0.301^{c} (2.327)
Taste Differences	+	0.003 (0.098)	0.052^{a} (1.400)	0.052^{b} (2.322)
SITC 71 Dummy	na	2.172^{c} (3.249)	1.547^{c} (2.332)	0.845^{b} (2.067)
SITC 73 Dummy	na	1.935^{b} (2.319)	1.070^{a} (1.293)	-0.026 (0.051)
Quasi-Constant	na	10.424^{c} (3.807)	6.348^{c} (2.335)	2.669^{a} (1.614)
Number of Observations		273	273	273
F-statistic		8.895**	10.030**	16.700**

The t-statistics are in parentheses. a, b, and c represent statistical significance in one-tail t-tests at the 10%, 5%, and 1% levels, respectively. "na" means not applicable. ** represents statistical significance for F-test at 1% level.

using 1976 trade flows, unlike the two previous indexes that use flows averaged over 1975-1977.

Table 4 presents the results of the first three regressions. In general, results are similar across regressions, although certain independent variables are statistically significant in the latter two regressions - using trade-balanced flows - that are not significant in the first regression. Foremost, the variable representing the degree of increasing returns and, implicitly, product differentiation has the anticipated positive coefficient estimate sign and statistical significance in all three regressions. Second, the lower the degree of effective tariff and nontariff protection, the greater the degree of IIT. This is consistent with the explanation that mutual trade liberalization can spur exploitation of gains from intra-industry specialization in minutely differentiated products, ideally lowering the factor reallocation costs of such liberalization. Third, wider relative factor intensity differences between trading partners in an "industry" decreases the share of trade overlap. This is consistent with the expectation that wider relative factor intensity differences increase the degree of inter-industry trade. Fourth, border trade does not appear to be a quantitatively important source of IIT. Distance's coefficient estimate is significant sometimes, but the adjacency dummy has the correct sign in only the third specification. Fifth, some IIT appears to be created by taste differences across nations. In regressions using trade-balanced trade flows, the taste differences variable's coefficient estimate has the expected positive sign and statistical significance.

Finally, coefficient estimates for the SITC 71 and SITC 73 dummy variables suggest a statistically significant difference in the average level of IIT across the three industries. Pooling increases a regression's explanatory power but constrains the estimated effect of each independent variable to be identical across industries. Is pooling restrictive here ? Do independent variables have widely different effects across industries ?

To illustrate that specifications in Table 4 are appropriate and estimated effects are not very restricted, the three specifications are estimated separately for each industry. For brevity, results are presented only for specification (2). Results for the other two specifications are similar but slightly less robust. The results are presented in Table 5. In general, coefficient estimate signs do not vary much across industries and are similar to those in regression (2). Though statistically insignificant, coefficient estimates for the increasing returns/product differentiation variable are correctly signed, close in value to estimates in Table 4, and very stable across industries. Formal

TABLE 5 : Regression Results by Individual Industries Composing SITC 7, Machinery and Transport Equipment

Variables	Expected Coefficient Estimate Sign	Regressions (4) SITC 71	(5) SITC 72	(6) SITC 73
Increasing Returns/Product Differentiation	+	0.537 (0.746)	0.518 (0.344)	0.417 (0.912)
Tariff	-	-0.134^{c} (2.410)	-0.112^{b} (2.368)	-0.070 (0.867)
Distance	-	0.169 (0.871)	-0.162 (0.886)	-0.147 (0.574)
Adjacency	+	0.083 (0.250)	0.165 (0.492)	-0.298 (0.742)
Factor Intensity Differences	-	-0.244 (0.985)	-2.465^{b} (2.891)	-0.599 (0.772)
Taste Differences	+	0.069 (1.075)	0.080 (1.280)	0.023 (0.330)
Quasi-Constant	na	1.197 (0.260)	31.823^{b} (2.076)	9.303 (0.814)
Number of Observations		91	91	91
F-statistic		5.544::	11.564::	1.094

The t-statistics are in parentheses. a, b, and c represent statistical significance in one-tail t-tests at the 10%, 5%, and 1% levels, respectively. "na" means not applicable. :: represents statistical significance for F-test at 1% level.

F-tests of equality of all coefficient estimates were calculated; results were mixed. For specification (1), an F-statistic of 2.326 indicates that equality can be rejected at the 1 percent significance level, but not at the 0.5 percent level. For specification (2), an F-statistic of 2.596 indicates that equality can be rejected at the 1 percent significance level, but not at the 0.1 percent level. For specification (3), an F-statistic of 5.569 indicates that equality can be rejected at the 0.1 percent significance level.

IV. CONCLUSION

This paper has focused on the major questions facing the understanding of IIT : How is IIT measured and is it prominent ? What causes IIT ? Can IIT be empirically explained ? The study attempted to integrate formal aspects of recent theoretical work into an econometric model explaining sources of IIT, using a new bilateral measure of IIT that filters out balance of payments influences.

In Part I, the proper measurement of IIT was analyzed. Recent developments in a generalized commodity version of the H-O theorem suggest that the relevant measure of IIT uses bilateral trade data. However, macroeconomic factors can bias IIT measures. A technique was developed to measure IIT using bilateral disaggregate data "simulated" to reflect multilateral aggregate trade balance. When employed, IIT indexes calculated from actual flows showed a tendency to understate the degree of IIT relative to indexes using trade-balanced flows. Furthermore, IIT is widespread and has grown substantially between 1965 and 1976.

In Part II, a theoretical model of IIT was developed with the demand side based upon work by Paul Krugman, the production side based upon neoclassical cost functions, and the market structure characterized by Chamberlinian monopolistic competition. In long-run equilibrium, the degree of product differentiation in an industry (a negative function of the elasticity of substitution) was shown to be a positive function of the degree of increasing returns (as measured by the elasticity of scale). Furthermore, the degree of IIT between two countries in an industry was shown to be a positive function of the implicit degree of product diversity in their trade.

In Part III, weighted least squares estimation of the logit of the IIT index was demonstrated to be the proper econometric methodology for estimation. Several independent variables were constructed to explain IIT - in differentiated or functionally homogeneous products. Several interesting conclusions arise from

the results. First, IIT does not appear to be merely an arbitrary consequence of product aggregation of essentially different industries. Second, IIT increases when pairs of countries specialize so as to exploit economies of scale in their trade. Third, greater product differentiation in the trade between two countries in an industry is consistent with a higher degree of IIT. Fourth, neither geographic adjacency of countries nor taste differences between countries were found to be prominent sources of IIT. Fifth, trade liberalization between pairs of countries tends to increase the share of IIT. This reflects a penchant for industrialized countries to favor trade liberalization in industries where product diversity and increasing returns are prominent and where the costs of reallocating factors are correspondingly low.

FOOTNOTES

1 Herbert Grubel (1967), Herbert Grubel and Peter Lloyd (1971, 1975), and Helmut Hesse (1974) provide comprehensive evidence for the existence of IIT at the 3-digit Standard Industrial Trade Classification (SITC) level. H. Peter Gray (1979) and Grubel and Lloyd (1975) offer selected evidence of IIT at the 5-digit SITC and 7-digit SITC levels, respectively.

2 Grubel and Lloyd (1975) provides a comprehensive review of pre-1975 theories of IIT.

3 Falvey assumes product differentiation but not increasing returns.

4 Pagoulatos and Sorensen did not include a measure of increasing returns.

5 Caves expected a negative sign for the coefficient estimate of his economies of scale variable, based upon intuition differing from the theoretical models cited earlier and differing from the other three empirical studies. This distinction, however, will be addressed later.

6 David Burgess (1974) claims that, "empirical evidence (suggests) that the bulk of international trade occurs in intermediate goods..." (p. 225). Kalyan Sanyal and Ronald Jones (1982) begins: "The bulk of international trade consists of the exchange of intermediate products, raw materials, and goods which require further local processing before reaching the final consumer" (p. 16).

7 Studies using a measure similar to A_i^k include Gray (1973, 1979), Hesse, Richard Pomfret (1979) and Caves.

8 Aquino demonstrates the problems associated with Grubel-Lloyd's adjustment method. Actually, Aquino adjusted trade data to reflect multilateral manufactures trade balance. Ignoring this issue for now, Aquino's adjustment method yields the index :

$$A_i^{k**} = 1 - [|X_i^{k**} - M_i^{k**}|/(X_i^{k**} + M_i^{k**})]$$

where

$$X_i^{k**} = [(X_i + M_i)/2X_i]X_i^k \qquad M_i^{k**} = [(X_i + M_i)/2M_i]M_i^k$$

and

$$X_i = \sum_k X_i^k \qquad M_i = \sum_k M_i^k$$

where X_i^k and M_i^k are defined earlier.

9 Loertscher and Wolter's bilaterally trade-balanced index is :

$$B_{ij}^{k**} = 1 - [|X_{ij}^{k**} - X_{ji}^{k**}|/(X_{ij}^{k**} + X_{ji}^{k**})]$$

where

$$X_{ij}^{k**} = [(X_{ij} + X_{ji})/2X_{ij}]\, X_{ij}^k$$

$$X_{ji}^{k**} = [(X_{ij} + X_{ji})/2X_{ji}]\, X_{ji}^k$$

and

$$X_{ij} = \sum_k X_{ij}^k \qquad X_{ji} = \sum_k X_{ji}^k$$

where X_{ij}^k and X_{ji}^k are defined earlier.

10 A simulation will demonstrate. Because the problem addresses multilateral aggregate trade balance for bilateral disaggregate trade flows, the example necessitates at least three countries (1, 2, 3) and two goods (A, B). Let the bilateral trade flows for each good be represented below.

A

		1	2	3	
	1	0	10	10	20
Exporter	2	15	0	5	20
	3	15	15	0	30
		30	25	15	70

B

		1	2	3	
	1	0	10	10	20
Exporter	2	10	0	10	20
	3	10	10	0	20
		20	20	20	60

In this example, initially country 1 has a (multilateral aggregate) trade deficit of 10, country 2 has a trade deficit of 5, and country 3 has a trade surplus of 15. Applying the transformation in equation (3) to matrices A and B yields (first) transformed matrices A** and B** :

A**

0	10.35	11.70	22.05
14.72	0	5.69	20.41
13.13	13.45	0	26.58
27.85	23.80	17.39	

B**

0	10.35	11.70	22.05
9.81	0	11.38	21.19
8.75	8.97	0	17.72
18.56	19.32	23.08	

Country 1's trade deficit is now 2.31, country 2's trade deficit is now 1.52, and country 3's trade surplus is now 3.83. Applying the transformation a second time yields matrices A**** and B**** :

A****

0	10.39	12.13	22.52
14.67	0	5.89	20.56
12.68	13.04	0	25.72
27.35	23.43	18.02	

B****

0	10.39	12.13	22.52
9.78	0	11.78	21.56
8.45	8.70	0	17.15
18.23	19.09	23.91	

Country 1's trade deficit becomes 0.54, country 2's trade deficit becomes 0.40, and country 3's trade surplus becomes 0.94. Applying the transformation iteratively will eventually yield trade flows that simulate multilateral aggregate trade balance (that meets some convergence criterion).

11 Numerous studies have focused on the "categorical aggregation issue". The issue suggests that higher levels of disaggregation would tend to eliminate arbitrary aggregation of essentially different industries. However, several reasons suggest that maximizing the level of disaggregation is not necessarily optimal in studying IIT. First, at higher levels of disaggregation trade data become less reliable and less representative. All trade statistics have minimum reporting levels below which trade is unreported. At high disaggregation levels, few small countries report trade flows because the volume of trade is reduced; consequently, sample representativeness is narrowed. Second, in studying the relative degree of IIT among industries, the level of aggregation may be irrelevant. Grubel and Lloyd (1975) tested the hypothesis that the relative degree of IIT is unrelated to the level of aggregation if the average of IIT indexes for industries composing an industry group is highly correlated with the IIT index for the industry group. The correlation coefficient between index averages of 3-digit SITC indexes and the corresponding 2-digit SITC index was 0.905. The same test for a 5-digit averaged index and the corresponding 3-digit index was 0.705. Grubel-Lloyd concluded that "this result implies that industries preserve their relative strength of IIT through these levels of aggregation, and studies of differences among industries would be insensitive to the level of aggregation chosen" (p. 51). Third, Gray (1979) demonstrated that an average IIT index calculated from highly disaggregated data is generally lower than the corresponding index calculated at a lower level of disaggregation for two reasons : "categorical aggregation and the weighting of component groupings by the value of their trade". Gray compared alternative IIT measures of several industries and concluded that "the data .... seem to point to weighting being every bit as important as categorical aggregation as a cause of the tendency for the values of (IIT) indexes to (decrease) with (higher) disaggregation ..." (p.98).

12 U.S. Bureau of the Census, Highlights of U.S. Export and Import Trade (1980), Tables E-9 and I-7.

13 OECD, Trade Series C - Trade by Commodities, 1979.

14 The 14 countries are Canada, United States, Japan, Belgium-Luxembourg, Denmark, France, West Germany, Italy, the Netherlands, United Kingdom, Austria, Norway, Sweden and Switzerland.

15 This assumption is tantamount to assuming each consumer's utility (and, hence, expenditures) is separable between this industry and others.

16 A formal treatment of this proposition is in Krugman (1982).

17 Baldwin (1970) estimated by industry group for each of the United States and United Kingdom nominal tariff rates and effective rates of tariff and nontariff protection. Correlation coefficients estimated across industry groups for these nominal and effective rates are 77.54 and 62.28 percent for the United States and United Kingdom, respectively.

18 For each country i in each industry k, the GATT nominal tariff rate is defined as :

$$t_i^k = [\sum_{s=1}^{S} (\sum_{r=1}^{R} z_r \cdot w_r / \sum_{r=1}^{R} w_r)_s W_s] / \sum_{s=1}^{S} W_s$$

where z_r is the tariff duty at the tariff level (r=1,...R tariff lines in a BTN heading), w_r is national imports in tariff line r, and W_s is world imports in BTN heading s (s=1,..., S BTN headings in an industry). For explanations of choices of weights, see GATT (1970), pp. 1-9.

19 We also calculated the tariff variable as :

$$TAR2_{ij}^k = \frac{X_{ij}^k}{X_{ij}^k + X_{ji}^k} t_j^k + \frac{X_{ji}^k}{X_{ij}^k + X_{ji}^k} t_i^k$$

where X_{ij}^k (X_{ji}^k) is the bilateral trade flow from country i to j (j to i) in 2-digit SITC industry k and t_i^k (t_j^k) is the GATT nominal tariff rate for country i (j) in industry k. Regression estimation using TAR2 rather than the simple average yields no noticeably different results.

20 See, for example, Jan Tinbergen (1962), Hans Linnemann (1966), Norman Aitken (1973), and Andre Sapir (1981). Countries' economic centers are specified in Linnemann, pp. 223-225.

21 This variable is formally defined as :

$$KL^{k}_{ij} = \sum_{m=1}^{M} \alpha^{km}_{ij} \; [(K/L)^{km} - (\overline{K/L})^{k}]^2$$

where α^{km}_{ij} is defined in the text, $(K/L)^{km}$ is the U.S. K-L input ratio for 3-digit product class m in industry k, and $(\overline{K/L})^{k}$ is the mean of all 3-digit K-L ratios in 2-digit SITC industry k. Physical capital stock figures are net current U.S. dollar plant and equipment stock figures for 1976 from the U.S. Bureau of Labor Statistics, Capital Stock Estimates for Input-Output Industries : Methods and Data, Bulletin 2034 (1979). See this bulletin for estimation methodology. Capital stock figures available by 3-digit U.S. SIC were cross-classified to 3-digit SITC. Often 3-digit capital stock figures were averaged to obtain a 3-digit SITC capital stock figure. Labor is total labor employed for 1976 and data are from U.S. Bureau of Labor Statistics, Employment Earnings, U.S. 1909-78, Bulletin 1312-11 (1979). Labor data, also by 3-digit US. SIC, were cross-classified to 3-digit SITC. The use of U.S. K-L ratios imposes a restriction of identical technologies across countries.

22 Regarding the similarity of industrialized countries' tastes, see H.S. Houthakker (1957) and Richard Caves and Ronald Jones (1973).

23 See, for example, Henri Theil (1971), pp. 628-636.

24 Of the four previous econometric studies, Caves and L-W noted the efficiency of estimation by weighted least squares. L-W inappropriately weighted only "the exogenous variables" (p.287). Ironically, the weights are needed most by the dependent variable as it is assumed stochastic and exogenous variables are nonstochastic. Second, in an OLS regression, $Var(u^{k}_{ij})$ is technically equal to $1/[n^{k}_{ij}\ IIT^{k}_{ij}\ (1 - IIT^{k}_{ij})]$; hence, the proper weight is $[n^{k}_{ij}\ IIT^{k}_{ij}\ (1 - IIT^{k}_{ij})]^{1/2}$ where n^{k}_{ij} is the number of observations (or transactions) generating IIT^{k}_{ij} (a proportion). Results in Tables 4 and 5 assume that $n^{k}_{ij} = 1$. Alternatively, I assumed that n^{k}_{ij} was proportional to the average level of transactions generating IIT^{k}_{ij}, i.e., $n^{k}_{ij} = 1/2\ (GDP_i + GDP_j)$ where GDP is gross domestic product of the respective country. Estimation with the alternative weights yielded similar results, available upon request from the author. Caves noted aspects of this second point but incorrectly weighted observations by

$$[n^{k}_{ij}\ IIT^{k}_{ij}\ (1 - IIT^{k}_{ij})]^{-1/2}.$$

APPENDIX A

This appendix extends a model developed by Jungho Yoo in an appendix in Baldwin (1979). Assume a three country (A, B, C), four commodity (1, 2, 3, 4), two factor (capital, labor) world where relative factor endowments and intensities are as follows:

$$(A1)\quad w_A/r_A > w_B/r_B > w_C/r_C$$

$$(A2)\quad (K/L)_1 > (K/L)_2 > (K/L)_3 > (K/L)_4$$

where w_i/r_i is the wage-rental ratio in country i (indicating relative factor abundances) and $(K/L)_k$ is the relative factor intensity in producing commodity k. Factor-intensity reversals and factor-price equalization are ruled out by assumption. Equations (A1) and (A2) imply :

$$\frac{UC_1^A}{UC_1^B} < \frac{UC_2^A}{UC_2^B} < \frac{UC_3^A}{UC_3^B} < \frac{UC_4^A}{UC_4^B}$$

$$(A3)\quad \frac{UC_1^B}{UC_1^C} < \frac{UC_2^B}{UC_2^C} < \frac{UC_3^B}{UC_3^C} < \frac{UC_4^B}{UC_4^C}$$

$$\frac{UC_1^A}{UC_1^C} < \frac{UC_2^A}{UC_2^C} < \frac{UC_3^A}{UC_3^C} < \frac{UC_4^A}{UC_4^C}$$

where UC_k^i is the unit cost of commodity k in country i.

The relationships in equation (A3) can be used to demonstrate, as in Yoo's appendix, that this commodity version of the H-O theorem holds for bilateral trade, but need not hold for multilateral trade. Yoo demonstrated that a country's multilateral trade can be inconsistent with the H-O theorem in an ordering sense, importing products from more and less relatively capital-abundant countries. However, Yoo did not extend his model to demonstrate that multilateral intra-industry trade (IIT) can occur in it, and bilateral IIT cannot.

Suppose that country B imports commodity 2 from country A and exports commodity 3 to A. The necessary conditions for this to occur are :

$$(A4)\quad UC_2^B > UC_2^A + c_2^{AB}$$

$$(A5)\quad UC_3^A > UC_3^B + c_3^{AB}$$

where c_k^{ij} is the cost of shipping a unit of commodity k between countries i and j. Equations (A4) and (A5) are consistent with equation (A3) because they imply $UC_3^A/UC_3^B > 1 > UC_2^A/UC_2^B$.

If the "dividing point" between countries B and C is the same as between A and B, we can suppose that C imports commodity 2 from B and exports commodity 3 to B. The necessary conditions for this to occur are :

$$(A6)\quad UC_2^C > UC_2^B + c_2^{BC}$$

$$(A7)\quad UC_3^B > UC_3^C + c_3^{BC}$$

Equations (A6) and (A7) are consistent with equation (A3) because they imply $UC_3^B/UC_3^C > 1 > UC_2^B/UC_2^C$.

However, note that country B exports good 2 to C and imports good 2 from A; multilateral IIT exists. The necessary conditions for this to occur are :

$$(A8)\quad UC_2^C - c_2^{BC} > UC_2^B > UC_2^A + c_2^{AB}$$

$$(A9)\quad UC_3^A - c_3^{AB} > UC_3^B > UC_3^C + c_3^{BC}$$

Equations (A8) and (A9) are not inconsistent with equation (A3) because they imply $(UC_3^A/UC_3^C) > (UC_3^B/UC_3^C + c_3^{AB}/UC_3^C) > 1 > (UC_2^B/UC_2^C - c_2^{AB}/UC_2^C) > (UC_2^A/UC_2^C)$. The potential existence of multilateral IIT is uninteresting (from our perspective) because it is not precluded by this version of the H-O theorem.

Yet, bilaterally measured IIT remains an interesting issue because it is precluded by this version of the H-O theorem. For example, for country B to import good 3 from country C and export good 3 to C, the necessary conditions are :

(A10) $UC_3^B > UC_3^C + c_3^{BC}$

(A11) $UC_3^C > UC_3^B + c_3^{BC}$

However, equations (A10) and (A11) are inconsistent because they imply $-c_3^{BC} > c_3^{BC}$, which is clearly false.

APPENDIX B

The elasticity of scale (production function coefficient) is defined as the percentage increase in output (output per worker) as all inputs are doubled. A common method for calculating the production function coefficient for several product classes, suggested in Gary Hufbauer (1970), is to estimate the following regression across plant size classes in each product group :

(B1) $V_g = \phi(Z_g)^\beta$

where V_g is the adjusted value added per worker in plant size class g, Z_g is the average number of workers employed in plant size class g, ϕ is a constant, and β is the production function coefficient. Adjusted value added in a particular plant size class is assumed proportional to total output ; capital is assumed to increase proportionately with labor.

The 1977 U.S. Census of Manufactures provides value added data by 4-digit U.S. SIC disaggregated across various plant size classes. The 4-digit U.S. SIC level is the most disaggregated level of value added data by plant size. To conform 4-digit U.S. SIC data to the SITC, several 4-digit product classes were pooled to compose a 3-digit SITC product class and value addeds were adjusted to account for differences across 4-digit SICs unrelated to scale of production. Production function coefficients were estimated for each of the 18 3-digit SITCs in SITC 7 ; estimates are presented in Table 6. The estimates generally suggest statistically significant initially increasing returns to larger plant size for product classes in SITC 7. The mean of 0.05 implies that long-run average costs fall by 5 percent, on average, as plant size doubles.

Finally, the relationship between unit production costs and scale of plant is appropriately represented by the loglinear relationship expressed in equation (B1). That is, the majority of product classes revealed that the minimum of the long-run average cost (AC) curve had not been reached by even the largest plants in the product class or the minimum was reached at the penultimate observation. For all 18 3-digit SITCs, the following quadratic regression was also estimated :

(B2) $V_g = \phi' + \beta' (Z_g) + \xi' (Z_g)^2$

The alternative hypothesis, $H_A : \xi' < 0$, tests for whether the data suggest a quadratic relationship in the proper direction (AC curve convex from below). In 14 of 18 SITCs, the null hypothesis, $H_0 : \xi' = 0$, could not be rejected at the 5 percent significance level, implying the absence of a quadratic relationship.

TABLE 6 : Parameter Estimates of the Production Function Coefficient for All 3-Digit SITC Product Classes in SITC 7*

SITC	Coefficient Est.	(t-stat)	n	SITC	Coefficient Est.	(t-stat)	n	SITC	Coefficient Est.	(t-stat)	n
711	.0789[c]	(2.97)	14	722	.0464[c]	(3.14)	21	731	.0427[a]	(1.58)	7
712	.1057[c]	(4.35)	14	723	-.0111	(-0.53)	14	732	.1191[c]	(4.17)	29
714	.0664[c]	(3.04)	26	724	.0356[c]	(3.35)	76	733	.0729[c]	(2.98)	23
715	.0433[c]	(3.06)	44	725	.0770[c]	(3.65)	40	734	.0535[c]	(2.59)	24
717	-.0176	(-0.58)	7	726	.0599	(1.23)	7	735	-.0022	(-0.19)	14
718	.0444[c]	(3.84)	78	729	.0530[c]	(4.71)	88				
719	.0332[c]	(3.74)	91								

* n is the number of observations. Observations do not include plants with less than 10 employees because these establishments presumably operate specialty trades that are quite different from ordinary plants. a, b, and c represent statistical significance in one-tail t-tests at the 10%, 5%, and 1% levels, respectively. Source of data : 1977 U.S. Census of Manufactures.

APPENDIX C

The taste differences variable used in Part III is based upon the following framework. Assume that individuals within countries have identical tastes so that preferences can be aggregated into a community indifference map. For tractability, assume that traded and nontraded goods are separable in utility and each individual in country j has a constant elasticity of substitution (CES) utility function for tradables. Because of identical tastes across consumers within a country, country j is assumed to have the utility function :

$$\text{(C1)} \quad U_j = \Big(\sum_{i \neq j}^{I} \sum_{m}^{M} a_{ijm} X_{ijm}^{\theta} \Big)^{1/\theta}$$

where a_{ijm} is the importance in country j's utility of country i's exports in product class m, X_{ijm} is country j's imports from country i in product class m, and θ is a positive function of the constant elasticity of substitution, $\rho(\theta = 1 - 1/\rho)$. Assuming that country j's tradable expenditures exhaust the budget for them, then :

$$\text{(C2)} \quad \sum_{i \neq j}^{I} \sum_{m}^{M} p_{ijm} X_{ijm} = Y_j^T$$

where p_{ijm} is the price of country i's exports to j in product class m and Y_j^T is tradable expenditures of country j. Maximizing equation (C1) subject to equation (C2) and solving the first order conditions for X_{ijm}/Y_j^T yields :

$$\text{(C3)} \quad x_{ij}^{km} = X_{ijm}/Y_j^T = (p_{ijm}^{-\rho} a_{ijm}^{\rho}) / \Big(\sum_{i \neq j}^{I} \sum_{m}^{M} p_{ijm}^{1-\rho} a_{ijm}^{\rho} \Big).$$

Thus, x_{ij}^{km} is the price-weighted relative importance in country j's tastes of country i's exports in product class m. Dissimilarity of country j's tastes from the other I-1 countries' tastes is revealed by:

$$\text{(C4)} \quad x_{ij}^{km} - \bar{x}_{i.}^{km} = p_m^{-\rho} \Big\{ a_{ijm}^{\rho} / \Big(\sum_{i \neq j}^{I} \sum_{m}^{M} p_m^{1-\rho} a_{ijm}^{\rho} \Big) - \frac{1}{I} \sum_{j=1}^{I} \Big[a_{ijm}^{\rho} / \Big(\sum_{i \neq j}^{I} \sum_{m}^{M} p_m^{1-\rho} a_{ijm}^{\rho} \Big) \Big] \Big\}$$

where $p_{ijm} = p_m$ (for all $i \neq j$) by the assumption of perfect commodity arbitrage and $\bar{x}_{i.}^{km}$ is the mean of x_{ij}^{km} across all j countries. ⁎ We can now define a cross-country independent variable to reflect taste differences of trading partners i and j in industry k :

$$TASD_{ij}^{k} = \frac{1}{2} \sum_{m=1}^{M} \big[(X_{ij}^{km}/X_{ij}^{k})(x_{ij}^{km} - \bar{x}_{i.}^{km})^2 + (X_{ji}^{km}/X_{ji}^{k})(x_{ji}^{km} - \bar{x}_{j.}^{km})^2 \big]$$

where X_{ij}^{km}, X_{ji}^{km}, X_{ij}^{k}, and X_{ji}^{k} are defined earlier and $(x_{ji}^{km} - \bar{x}_{j.}^{km})$ is constructed for country i in the same manner as in equations (C3) and (C4).

⁎ The dissimilarity of country j's tastes from the norm is even clearer if I make the further "conventional" assumption, suggested in James Anderson (1979), that "with cross-section analysis, prices are constant at equilibrium values and units are chosen such that they are all unity" (p. 108).

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