# The Scope, Growth, and Causes of Intra-Industry International Trade

By Jeffrey H. Bergstrand*

Sake — commonly considered a rice wine though more properly a beer — is regarded as the national beverage of Japan. Its prominence is historically linked to many drinking customs and rituals for various religious and social occasions. Some months ago, a *New York Times* article illustrated the tense trade relations between the United States and Japan by citing the stiff tariff duties imposed by one country on imports of sake from the other. The irony was that the United States was the exporter and Japan was the importer!

One expects Japan to export rather than import sake. In fact, Japan and the United States each exports *and* imports sake. This seemingly incongruous fact is an example of what has come to be known as "intra-industry international trade." 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."

The existence of IIT is puzzling. Traditional trade theories predict that a country will export products of an industry in a given year if domestic demand for the industry's products falls short of domestic production, or will import products if domestic demand exceeds domestic production. Yet, the existence of IIT indicates that a country exports and imports products in the industry simultaneously.

One explanation for this apparent inconsistency is that products simultaneously exported and imported in an industry are *not* perfect substitutes. A typical consumer does not view a Cadillac and a BMW as perfect substitutes. A Michelob is not a perfect substitute for a Kronenbourg. Thus, products that the consumer perceives as different may be produced by essentially the same technique, that is, by the same industrial process.

Recognizing these product differences, some economists claim that domestic producers tend to specialize in styles of products appealing to the majority of domestic households. As countries achieve high per capita incomes, consumers' tastes diversify — leading to imports of styles appealing to various minority tastes. However, this explanation raises certain questions. First, is there justification for these economists' assumption that national tastes differ across industrialized countries? Are these differences determined by economic forces? Second, 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? Third, suppose the industry is comprised of a wide range of minutely differentiated products with each firm producing a unique product. Is it possible that IIT could be avoided by refining the definition of an industry? That is, if each country's redefined industry could produce a different range of somehow "related" products, could IIT be ruled out? All of these questions are addressed in this article.

One common way of quickly dismissing IIT on empirical grounds is to argue that the trade data arbitrarily group into an industry goods that are produced using different techniques and are not even close substitutes. For example, U.S. trade statistics are classified according to the U.S. Standard Industrial Classification (SIC) scheme. SIC 363 is household appliances. A breakdown of this category reveals that it includes products such as stoves, freezers, and washing machines — not very close substitutes.

Nevertheless, IIT persists within even more detailed trade categories. Table 1 presents data for trade

* Economist, Federal Reserve Bank of Boston. The author is grateful to Saul Schwartz for helpful discussions and Susan Tamir for research assistance.

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

| (1) Product | (2) U.S. Trading Partner | (3) U.S. Exports to: | (4) U.S. Imports from: | (5) IIT Index* |
|---|---|---|---|---|
| | | ($) | ($) | |
| Antifriction Rollers | EC | 723,927 | 5,390,246 | 0.237 |
| | Japan | 7,500 | 31,173 | 0.388 |
| Cigarettes | EC | 201,257,440 | 8,547,679 | 0.082 |
| | Japan | 40,119,670 | 54,032 | 0.003 |
| Magnetron electronic microwave tubes | EC | 3,439,718 | 2,126,534 | 0.764 |
| | Japan | 1,698,369 | 1,366,334 | 0.892 |
| Metal bending and forming machine tools, over $2500 | EC | 9,257,191 | 15,265,584 | 0.755 |
| | Japan | 5,708,577 | 2,804,485 | 0.659 |
| Metalworking gear tooth grinding and finishing machines | EC | 839,082 | 2,222,057 | 0.548 |
| | Japan | 830,605 | 1,005,797 | 0.905 |
| New passenger automobiles | EC | 321,604,059 | 4,002,794,157 | 0.149 |
| | Japan | 117,067,901 | 6,663,726,849 | 0.035 |
| Offset printing presses, roll-fed type, weighing 3500 lbs. or more | EC | 17,922,423 | 7,638,747 | 0.598 |
| | Japan | 1,201,060 | 114,043 | 0.173 |
| Sodium compound, bicarbonate | EC | 178,630 | 279,034 | 0.781 |
| | Japan | 10,793 | 1,181 | 0.197 |
| Stainless steel bars, angles, shapes, rolled flats, and squares | EC | 704,805 | 781,236 | 0.949 |
| | Japan | 3,603,947 | 5,429,191 | 0.798 |
| Thyristors | EC | 11,575,465 | 7,370,046 | 0.778 |
| | Japan | 888,112 | 1,081,609 | 0.902 |

*The intra-industry trade index represents the proportion of trade in each product between partners that "overlaps."

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.

between the United States and both the European Community (EC) and Japan in 10 narrowly defined products. Even for products as narrowly defined as these, the United States exports and imports sizable amounts of each product with each trading partner. Columns 3 and 4 list U.S. exports to and imports from trading partners indicated in Column 2.

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. This specially constructed index provides a basis for comparing the degree of IIT across products and across pairs of trading partners. Consider the eighth product listed in Table 1. The United States exports $178,630 of bicarbonate of soda — a chemical manufacture — and imports $279,034 of the same product in trade with the EC. The total value of trade between the two partners ($457,664) can be separated into two distinct components: trade that "overlaps" (or IIT) and trade that does not "overlap" (or inter-industry trade). Since U.S. exports of the product fall short of imports by $100,404, this is the value of trade that does *not* overlap. Hence, the value of trade overlap between these trading partners in this product is the difference, $357,260 (or $457,664 − $100,404). To facilitate a comparison of trade overlap across industries, each trade overlap value is divided by the total trade value (in the example, $457,664). Thus, the IIT index (0.781) measures the share of trade between a pair of countries in a particular industry that "overlaps."[1] Column 5 indicates that the degree of IIT is high for several of these narrowly defined products.

Part I of this paper examines the scope and growth of IIT. We investigate the extent of IIT across the various industries composing Machinery and Transport Equipment (one of four manufacturing industry groups). Issues addressed include the concept of an industry, proper measurement of IIT, and the prevalence of IIT at a level widely recognized as an "industry." The growing importance of IIT in industrialized countries' trade is also examined.

---

[1] Formally, the IIT index is defined as:

$$(1)\ IIT^k_{ij} = 1 - [|X^k_{ij} - X^k_{ji}|/(X^k_{ij} + X^k_{ji})]$$

where $X^k_{ij}$ ($X^k_{ji}$) 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 industry k from country i to j is matched by an identically sized flow from j to i, IIT in industry k 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.

Part II of this paper examines, compares, and contrasts causes of IIT. Among these causes, increasing returns to scale and product differentiation are expected to be prominent. Empirical investigation suggests that the degree of increasing returns to scale and product differentiation and the extent of government-induced trade liberalization are important in explaining IIT. Part III offers some concluding remarks and discusses policy implications.

## *Part I. The Scope and Growth of Intra-Industry Trade*

IIT is a widespread phenomenon. In a majority of observations, this study has found trade in manufactured products to be more intra-industry than inter-industry in nature. The new measure of IIT introduced here shows that the usual measure tends to *understate* the degree of IIT in an industry. Finally, the recent rapid growth of IIT is examined.

### A. The Measurement and Scope of Intra-Industry Trade

Three questions are addressed in this section. First, what is meant by the term "industry"? Second, when IIT is properly measured, is it more or less prevalent than previously supposed? Third, is IIT extensive?

Before considering the definition of an "industry," note that IIT primarily arises within manufacturing industries. This fact is not fortuitous. In the typical *non*-manufacturing industry, such as wheat growing or copper mining, any two firms' products are viewed by consumers as perfect substitutes, and the firms use very similar production methods and combinations of capital and labor. Production is also assumed to be characterized by "constant returns to scale." That is, proportionate increases in capital and labor yield a proportionate increase in output. The typical nonmanufacturing industry is said to produce a "perfectly homogeneous product" under constant returns to scale.

In manufactures, composing the bulk of trade among industrialized countries, products are usually the result of hundreds of production steps or tasks.[2] The large number of tasks and intrinsic complexity of manufactures' production suggest that each firm's product in an industry should be viewed as a distinct set of characteristics; each firm's product combines characteristics in slightly different proportions. Consequently, no two manufacturing firms' products can ever be considered perfect substitutes by consumers.

On the production side, any two firms in an industry — manufacturing or nonmanufacturing — should use identical (and the most efficient) production technologies and combinations of capital and labor. However, unlike nonmanufactures, the large number of tasks and intrinsic complexity of manufactures' production imply that their production is often characterized by "increasing returns to scale" over the range of output realized by the typical firm. Cost per unit of output will fall with a larger scale of production for several reasons. First, a larger scale plant entails a larger pool of productive factors where workers can specialize in different tasks, become proficient regardless of natural talents, and avoid setup costs associated with movements from task to task. Second, indivisibilities in specialized machinery lead to increasing returns to larger plant size. In many manufacturing processes, specialized machinery has been designed that can perform tasks at considerable cost savings, but only at a large scale of production. For example, steel production requires large plants to accommodate specialized large blast furnaces, basic oxygen furnaces, continuous casting, and energy recovery systems. Third, even when large and small plants use the same machine, the former gains from longer production runs. A larger scale of output and plant size suggests that fixed costs may be spread out over more units of output. A fourth source of increasing returns is "economies of massed reserves." For continuous operation, a small firm using a single, specialized machine may have to double capacity to insure against a machine breakdown. For large plants this insurance (a fixed cost) is not such a large proportion of costs. However, increasing returns usually are not unlimited. Decreasing returns usually arise from managerial bottlenecks. In all operations, there is only one president — the ultimate bottleneck to insure that at least one productive factor remains fixed as plant size increases.

Thus, a practical definition for a manufacturing industry is a group of firms producing goods under variable returns to scale that consumers view as close, yet imperfect, substitutes and using identical production technologies and combinations of capital and labor. By contrast, traditional trade theories assume that consumers view all products of an industry as perfect substitutes. Furthermore, these theories presume constant returns to scale in production. Traditional trade theo-

[2] For example, "The Japanese Chip Challenge" (*Fortune*, March 23, 1981) reports that "making semiconductor devices involves more than 400 steps and requires some of the most intricate manufacturing processes ever devised" (p. 118).

ries seem more suitable for describing only nonmanufactures trade.

Setting boundaries around specific manufacturing industries is more difficult. However, several reasons exist for selecting the 3-digit Standard Industrial Trade Classification (SITC) as representative of an industry.[3] The most compelling reason is that "the 3-digit SITC statistics separate commodities into groups most closely corresponding to the concept of an 'industry' used conventionally in economic analysis."[4]

With the boundaries of an industry established, we can address the proper measurement of IIT. This section presents an alternative measure of IIT to the usual one, used in Table 1. The usual measure is shown to understate the degree of IIT relative to the new measure.

The IIT indexes in Table 1 were estimated using *actual* trade flow data. Actual trade flows, however, may incorporate undesirable biases created by balance of payments influences. For example, in a fixed exchange rate world a balance of payments deficit implies shrinking official monetary reserves that tend to shrink domestic expenditures and the volume of imports. Alternatively, the deficit country may be obliged to devalue its currency, a step that generally makes its exports more competitive and imports less attractive. Thus, actual trade flow data are influenced by macroeconomic factors as well as by patterns of specialization, while a desirable measure of IIT should reflect specialization patterns only.

To insulate the IIT measure from balance of payments influences, an alternative IIT index is formulated that replaces actual trade flows with flows adjusted to reflect "trade balance." Essentially, each actual bilateral trade flow is multiplied by a specially constructed factor comprised of aggregate exports and imports of the relevant pair of countries. For example, if a particular bilateral flow is artificially low because the exporter has an aggregate trade deficit and the importer an aggregate trade surplus, the factor adjusts the actual flow upward. Repeated adjustments eventually yield trade flows "simulated" to reflect trade balance. In all other respects, the alternative IIT index is calculated as in Table 1. A boxed insert in the appendix demonstrates formally the simulation method and provides an example.

Finally, before measuring the extent of IIT, a sample of trade data must be selected. As noted earlier, IIT is primarily a characteristic of manufacturing industries. However, estimating the extent of trade overlap for all 3-digit SITC manufacturing industries is far beyond the scope of this paper. Fortunately, manufactures can be separated into four general (1-digit SITC) industry groups — one of which is clearly representative, for our 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 nonconsumer goods were 9 percent and 91 percent, respectively, of U.S. exports in SITC 7. For the same year, consumer and nonconsumer goods were 13 percent and 87 percent, respectively, of all U.S. (nonmilitary) manufactures exports.

Second, even though SITC 7 is only one of several 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.

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). In a previous study, the IIT index averaged over all manufactures was 0.57. For SITC 7, the average IIT index was 0.59. However, IIT indexes for SITCs 5, 6, and 8 were 0.66, 0.49, and 0.52, respectively.[5] Thus, SITC 7 stands out as the industry group most representative of all manufactures. The first column in

[3] The "categorical aggregation issue" suggests that higher levels of disaggregation would tend to eliminate arbitrary aggregation of essentially different industries. However, at least two 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 higher disaggregation levels, few small countries report trade flows because the volume of trade is reduced; consequently, sample representativeness is narrowed. Second, H. Peter Gray ("Intra-Industry Trade: The Effects of Different Levels of Data Aggregation," in H. Giersch (ed.), *On the Economics of Intra-Industry Trade*, Tubingen, Germany: J.C. Mohr, 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).

[4] H.G. Grubel and P.J. Lloyd, *Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products* (New York: John Wiley and Sons, 1975), p. 52.

[5] Ibid, p.37.

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) |
| 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 (.58) | .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) |

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.
Source: OECD *Trade Series C — Trade by Commodities, 1976.*

Table 2 lists the 3-digit industries composing this SITC industry group.

Indexes of IIT were calculated for each possible pairing of countries among 14 major industrialized countries.[6] The indexes were calculated using both actual and trade-balanced trade flows for 1976 for each industry in SITC 7. To consolidate results, an average was computed for each industry of each country's 13 IIT indexes with its 13 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 trade flows; the parenthetical number in each entry is the index average calculated from trade-balanced trade 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-

[6] The 14 countries are Canada, United States, Japan, Belgium-Luxembourg, Denmark, France, West Germany, Italy, the Netherlands, United Kingdom, Austria, Norway, Sweden, and Switzerland. R.E. Baldwin ("Determinants of Trade and Foreign Investment: Further Evidence," *Review of Economics and Statistics* 61 (February 1979), pp. 40–48) and others have shown that in a multicountry, multicommodity, two-factor, factor price nonequalized world, the commodity version of the Heckscher-Ohlin theorem need not hold for a country's multilateral trade, but will hold for any pair of countries. With this development, estimates of IIT using multilateral trade data (the most common empirical method) are less relevant and estimates using bilateral trade data are more relevant.

half of the entries (either actual or trade-balanced trade flows) exceed 0.50, implying that trade between pairs of countries for these industries is more intra-industry than inter-industry in character. Third, there is a strong tendency for IIT indexes calculated from trade-balanced trade flows to exceed those calculated from actual trade flows. Almost two-thirds of the indexes calculated from trade-balanced trade flows are higher than indexes calculated from actual trade flows. Furthermore, the difference is sometimes quite large. For instance, in the telecommunications apparatus industry (SITC 724), Japan's IIT index using trade-balanced trade flows is 90 percent higher than the index using actual trade flows. Thus, while Table 1 showed that IIT does not disappear for even the most narrowly defined industries, Table 2 reveals not only that trade overlap is widespread but that it is much more intense than the usual measure suggests.

### B. The Growth of Intra-Industry Trade

The intent of this brief section is to examine the growth of trade overlap. Analysis over time permits examination of the importance of IIT 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 growth in the index average for the period 1965 to 1976 was calculated.

Table 3 presents the results. 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. The results in Table 3 clearly suggest widespread growth in IIT across industries and countries, as 75 percent of the entries are positive. The United States has observed substantial IIT growth in nonelectric power generating machinery, machinery for special industries, electricity distributing equipment, medically related electrical apparatus, and aircraft manufactures.

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. The second half of this article addresses this subject.

## *Part II. Causes of Intra-Industry Trade*

Traditional theories of why nations trade are based upon the principle of comparative advantage. These traditional explanations suggest that under certain assumptions a country will *not* simultaneously export and import products in the same industry. Hence, the prominence and growth of IIT is perplexing.

Causes of IIT are separated into two general categories. The first, IIT in "homogeneous" products, is regarded as the outcome of violations in the real world of the traditional theoretical assumptions. These assumptions include: no governmental distortions of markets; no transportation, selling, or information costs; and the production and consumption of all products at a single point in time. Departures from any of these assumptions permit IIT in "homogeneous" products, that is, products that consumers otherwise view as perfect substitutes and that firms produce using identical technological methods and combinations of capital and labor.

If traditional assumptions did hold in reality, much IIT would vanish but — as will be explained shortly — much would still remain. A second category of IIT is trade in "differentiated" products. In the typical manufacturing industry, the large number of tasks and intrinsic complexity of production suggest that each firm produces under initially increasing returns to scale — using the same basic technology and combination of capital and labor — a product that differs slightly from products of other firms in the industry. Inherent differences between manufacturing and nonmanufacturing industries give rise to a relatively greater degree of IIT in manufactures.

This part of the article also describes potential effects on IIT of actual taste differences across nations and actual differences in the combinations of capital and labor used to manufacture products in the same "industry." The last section summarizes results of statistical tests designed to explain IIT. The degree of increasing returns and product differentiation and the extent of government-induced trade liberalization are prominent in explaining IIT.

### A. Traditional Trade Theories

> Nations trade with each other for fundamentally the same reasons that individuals or regions engage in exchange of goods and services: to obtain the benefits of specialization.[7]

[7] M.E. Kreinin, *International Economics* (New York: Harcourt, Brace, Jovanovich, Inc., 1979), p. 214.

productive resources and export excess production in those industries.

In both traditional explanations, international trade between countries is solely *inter*-industry trade — that is, there is no trade overlap. In both cases, gains from trade arise because of innate differences between countries in technologies or in relative endowments of productive resources. The puzzling fact is that IIT is prominent among countries where innate differences are virtually *absent*. That is, IIT is extensive among industrialized countries sharing nearly identical tastes, technologies, and relative endowments of productive factors. Thus, traditional trade theories do not provide a full explanation of international trade.

### B. Causes of IIT in Homogeneous Products

The traditional static trade theories just discussed 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.

Governments use tariffs, quotas, subsidies, etc. to "protect" domestic industries from international competition. However, the extent and complexity of government interference has been cited as a cause of two-way trade. One study has noted 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."[8] Tariff and nontariff barriers can also influence IIT in differentiated products, and this aspect will be discussed in detail in the next section. Consequently, an explanatory variable representing the degree of tariff and nontariff protection between pairs of countries is included in the statistical analysis.

Although traditional trade theories assume that transportation, selling, and information costs of international exchange (henceforth, called transport costs) are insignificant, transport costs may be, in reality, a substantial portion of unit price. As a result, 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 prominent source of IIT, the influence of transport costs must be measured. Distance (in nautical miles) between economic centers of trading partners has been found to be a good index of transport costs.[9] To account as well for special economic relations that develop between neighboring countries owing to cultural, historical, and/or language ties, a variable representing geographic adjacency is included in the statistical analysis.

Just as traditional trade theories ignore transport costs, these theories also 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 commodities that would not exist otherwise. To suppress the influence of such cyclical demand conditions, the statistical analysis uses IIT indexes 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 minor. For the United States in 1980, for example, reexports accounted for only 1.9 percent of all exports. Consequently, such trade is ignored.

### C. Causes of IIT in Differentiated Products

IIT need not be the outcome only of "imperfections" such as those discussed in the preceding section. Minor variation in products is another source of such trade. However, as noted in the introduction, three related questions arise. Does IIT in differentiated products arise because industrialized countries have essentially dissimilar tastes? If consumers like diversity, can each country be better off producing only *some* products in the industry and exchanging these products internationally? What prevents each country's "industry" from producing a spectrum of somehow "related" products such that these products could be grouped into distinct (redefined) industries in each country with no IIT remaining?

One frequently cited explanation for IIT in differentiated products among industrialized countries is that countries' tastes are essentially different. According to this view, products of each country's industry reflect

[8] Grubel and Lloyd, *Intra-Industry Trade*, p. 83.

[9] The use of distance as a proxy for transport costs in explaining bilateral trade flows in cross-country regressions is successful in (among others) J. Tinbergen, *Shaping the World Economy: Suggestions for an International Economic Policy* (New York: The Twentieth Century Fund, 1962); H. Linnemann, *An Econometric Study of International Trade Flows* (Amsterdam: North-Holland Publishing Co., 1966); N.D. Aitken, "The Effect of EEC and EFTA on European Trade: A Temporal Cross-Section Analysis," *American Economic Review*, 63 (1973), pp. 881–892; and A. Sapir, "Trade Benefits under the EEC Generalized System of Preferences," *European Economic Review*, 15 (1981), pp. 339–355.

tastes of the majority at home; minority tastes are met by imports. However, much empirical work suggests that industrialized countries' tastes are *similar*.[10]

Suppose that nations' tastes are, in fact, identical. Then, why do nations trade differentiated products? Nations trade because the typical consumer in every industrialized country likes diversity. For example, a two-car household may have one Chevrolet and one Ford, or one Chevrolet and one Datsun. An individual may own several shirts produced by various domestic and foreign firms. Thus, taste differences among individuals within a country or across countries are not necessary for the occurrence of IIT. Trade overlap results partially because each consumer demands a diversity of products. The greater the diversity of products (or extent of product differentiation), the greater the degree of IIT.

Tastes for product diversity alone do not guarantee the presence of IIT, however. If each firm had constant costs per unit of output regardless of the volume of output and if cost conditions were the same in each country, tastes for product differentiation could be accommodated efficiently by each country's domestic industry. Capital and labor could always be reallocated among various products to suit national tastes without any loss in productive efficiency. That is, a country would be indifferent between self-sufficiency in all products or specializing in only some products and exchanging products internationally.

However, given the existence of product differentiation, the large number of tasks and intrinsic complexity of manufactures' production suggest that production of a unique good by each of many firms is characterized by increasing returns to scale. That is, unit costs of production fall as output rises within the range of production customarily experienced by each firm.[11] As a result, countries can be better off if their respective industries' firms specialize in only *some* of the industry's products and products are exchanged internationally so that each country can consume all types of the industry's products.

The boxed insert demonstrates the gains from in-

[10] For example, see H.S. Houthakker, "An International Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law," *Econometrica*, 25 (1957), pp. 532–551, and R.E. Caves and R.W. Jones, *World Trade and Payments* (Boston: Little, Brown, and Co., 1973), p. 198.

[11] Such a situation is characterized by "monopolistic competition"; see E.H. Chamberlin, *The Theory of Monopolistic Competition* (Cambridge, MA: Harvard University Press, 1933).

**Welfare Gains from Intra-Industry Specialization**

Suppose the industry has 20 laborers allocated to it, 10 for each firm. One possible production scenario, assuming full employment, is that each firm uses its laborers to produce equal proportions of both products. If there is an input-output ratio of one to one when each firm allocates its labor in this way, then the following output pattern results:

| | *Output X* | *Output Y* |
|---|---|---|
| Firm A | 5 | 5 |
| Firm B | 5 | 5 |

where output of good X (good Y) is labeled Output X (Output Y). Consumers enjoy total industry output of 20 units, both goods consumed in equal proportions.

In the presence of potential increasing returns, Firm A may "tend" to specialize in good X (8 laborers in X, 2 in Y) and Firm B may "tend" to specialize in good Y (2 laborers in X, 8 in Y), in order to take advantage of more than proportionate increases in output to incremental labor increases. Suppose output rises 1.25 percent for each 1 percent increase in labor. The cumulative effect on outputs of unit changes in the allocation of labor is:

| | *Output X* | *Output Y* |
|---|---|---|
| Firm A | 8.90 | 1.65 |
| Firm B | 1.65 | 8.90 |

Consumers now enjoy total industry output of 21.10 units.

Complete specialization by each firm (that is, A in good X, B in good Y) suggests the maximum gains from specialization:

| | *Output X* | *Output Y* |
|---|---|---|
| Firm A | 11.72 | 0 |
| Firm B | 0 | 11.72 |

Consumers now enjoy the maximum industry output, 23.44 units, with the same amount of labor (20) owing to increasing returns. It can similarly be shown that identical gains arise if A specializes in good Y and B in good X.

tra-industry specialization. First, suppose the domestic economy is closed (that is, no trade is permitted) and consists of a single industry. The example demonstrates that total potential industry output is greater with firm specialization than if each firm produces both products. If households consume portions of both products — reflecting their tastes for diversity — domestic consumers are better off as long as each firm specializes and increasing returns are exploited. Alternatively, consider the industry as an international one; suppose each of the two firms is in a different country. If consumers in both countries have tastes for diversity, they are better off if each firm (country) specializes, increasing returns are exploited, and countries exchange products.[12] Both countries are better off with IIT!

Thus, the two countries are mutually better off when each specializes in only some of the industry's products and both exchange products, even if the countries have the same tastes, productive techniques, and resource endowments. However, what prevents each country's "industry" from producing a spectrum of somehow "related" products such that these products could be grouped into distinct (redefined) industries in each country with no IIT remaining?

The theory of IIT in differentiated products, based upon the gains from "acquired" rather than "natural" efficiency, presumes — unlike traditional trade theories — that countries possess *no* innate differences. The theory asserts that by specializing in particular tasks laborers in a firm acquire proficiency and avoid setup costs associated with movements from task to task — regardless of innate talents. Similarly, in the absence of international trade, all firms in an industry — regardless of country — could initially be identical. However, upon specializing each firm gains proficiency in its unique product and avoids retooling costs associated with movements from product to product; each firm can produce its unique product at a lower unit cost. Comparative advantages in minutely differentiated products are "acquired" by firms.

There is no reason to assume that such acquired advantages should fall into any particular pattern. Thus, it is most unlikely that any country would develop a comparative advantage in a specific "range" of the industry's products.[13] Even for the auto industry,

> . . . with some exceptions, (automobile) vehicles are today interchangeable around the world. Although there is an array of differentiated products, most are adaptable, with some modifications, to many geographical markets. Increasingly, therefore, vehicles are competitive across national boundaries in terms of price and quantity.[14]

Therefore, the degree of IIT between a pair of countries in an industry should be strongly related to the degree of product diversity and increasing returns to scale implicit in the trade between the countries. For the statistical analysis, separate explanatory variables representing both sources of IIT should be included. However, in market equilibrium, the degrees of product differentiation and increasing returns to scale are positively related.[15] Hence, only a single explanatory variable is needed and we have constructed one that measures the degree of increasing returns implicit in trade within an industry between a pair of countries.

Section B discussed how tariff and nontariff bar-

[12] The term "exploitation of increasing returns" may be ambiguous given two alternative perspectives. In the text, "exploitation" refers to greater completeness in specialization of firms — holding market structure constant. The market structure presumed is monopolistic competition. Alternatively, one might view exploitation of increasing returns as a changing market structure, where a few oligopolistic firms replace many monopolistically competitive firms. The latter view suggests that exploitation of increasing returns is correlated with *less* IIT, as fewer firms cause industry production to become more geographically concentrated (in the limit, a single country is exporter and no IIT can exist). Our empirical analysis estimates the effect of a higher degree of increasing returns on the degree of IIT in a cross-country framework for a given industry (i.e., market structure is constant, by construction). Thus, cross-country estimation is consistent with the text's use of the term exploitation. However, cross-industry estimation in previous empirical work allows — by construction — variation in market structures. This suggests a possible reason why previous empirical work has found a negative correlation between an elasticity of scale measure and the degree of IIT. See J.M. Finger and D.A. DeRosa, "Trade Overlap, Comparative Advantage and Protection," in H. Giersch (ed.), *On the Economics of Intra-Industry Trade*; R. Loertscher and F. Wolter, "Determinants of Intra-Industry Trade: Among Countries and across Industries," *Weltwirtschaftliches Archiv* 116 (1980), pp. 280–293; and R.E. Caves, "Intra-Industry Trade and Market Structure in the Industrial Countries," *Oxford Economic Papers* 33 (1981), pp. 203–233.

[13] For example, American, Japanese and European dynamic random access memory (RAM) semiconductor chip makers produced the 16K RAM, which has 16,000 (16,384 to be exact) memory cells on a single chip. Since the tooling-up cost to make more powerful chips is very high, the next chip produced was the 64K. To produce the more powerful chip, most Japanese firms simply "scaled up" the technique for the 16K RAM. The number of memory cells was quadrupled, but so was the size of the wafer (or chip). Some American firms offered a slightly different approach. Since consumers of these chips are indifferent to the size of the chip, the American firms could lower unit costs by increasing cell density, i.e., a less than proportionate increase in wafer size to the increase in cell number. The latter approach led to the "soft-error problem," according to "Japan's Ominous Chip Victory" (*Fortune*, December 14, 1981). Because of increased density, the smaller chips suffered from radiation emissions that erased the electrical charges that store information in memory cells. However, product differentiation need not be along nationalistic lines. According to the *Fortune* article, "Motorola took a different tack. It approached the challenge of the 64K much as the Japanese did, by choosing a conservative chip design" (p. 55). Thus, American producers compete relatively equally with other domestic as well as foreign firms.

[14] Marina v. N. Whitman, "International Trade and Investment: Two Perspectives," *Essays in International Finance*, Princeton University, Dept. of Economics, No. 143, July 1981, p. 7.

[15] The relationship between the degree of increasing returns (or elasticity of scale) and degree of product differentiation is developed in a theoretical supplement available from the author upon request.

riers to trade can cause IIT in homogeneous products. Such government interference in markets can also affect IIT in differentiated products. Trade liberalization (that is, government-induced reductions in tariff and nontariff barriers) generally encourages international trade, both inter- and intra-industry trade. But there is a reason to believe that such liberalization will stimulate IIT more than inter-industry trade, thereby increasing the degree of IIT.

When two countries mutually eliminate artificial trade barriers — for example, in the formation of the EEC — the domestic price of the imported product declines in each country. If the domestic and foreign products are perfect substitutes — as in the case of a typical nonmanufacturing industry — then domestic suppliers would be displaced by foreign suppliers, if the latter are the lower cost producers. The displacement of domestic productive resources previously employed in the industry could be large and costly.

However, when products are differentiated, mutual trade liberalization lowers the domestic price of an imported product in each country, but domestic products are not as easily displaced because they are imperfect substitutes. Domestic price reductions of imported products could simply increase the share of consumer expenditures allocated to an industry, without imports extensively displacing domestic products. Consequently, the displacement of domestic productive resources in the industry could be small and not very costly.[16]

Thus, mutual trade liberalization will occur primarily in those industries where product diversity and increasing returns are prominent, because these characteristics of an industry reduce the inevitable costs of reallocating productive factors. Hence, trade liberalization is expected to increase the level and degree of IIT. As a result, an explanatory variable representing the degree of tariff and nontariff protection between two countries within an industry is included in the statistical analysis.

## D. Other Causes of IIT

Our explanation of causes of IIT in differentiated products relies upon several restrictive assumptions. This section considers some additional causes that might become operative if two of our assumptions fail to hold.

First, we have assumed that an industry is comprised of firms using identical combinations of capital and labor to make all products. In reality, wide differences in capital-labor ratios among groups of products in an industry exist and these differences can influence the degree of IIT. Recall that both 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 a pair of countries in an "industry" is dominated by product groups using widely different ratios of capital to labor, the countries are effectively exchanging products of *different* industries — that is, of different industrial processes. Thus, trade is more inter-industry in character, and the IIT index should decline. An explanatory variable is included in the statistical analysis that measures the extent to which trade between two countries in an industry is dominated by products of essentially different production processes.

Second, we have assumed that industrialized nations have identical tastes. In reality, tastes among these nations may be similar, but not identical. 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.[17] If trade is dominated by product groups of disproportionate importance, suggesting differences in tastes, the degree of IIT should be higher. Some IIT — though not necessarily a quantitatively significant amount — is expected to be created by differing tastes across countries.

## E. Empirical Results

Standard statistical tests have been applied to determine whether the various foregoing explanations of IIT are in accordance with the relevant data. In general, the evidence supports the preceding explanations. The appendix presents these results in technical detail.

Foremost, the greater the extent of product diversity implicit in the trade between two countries in an

[16] A formal treatment of this proposition is in Paul Krugman, "Trade in Differentiated Products and the Political Economy of Trade Liberalization," in J. Bhagwati (ed.), *Import Competition and Response* (Chicago: National Bureau of Economic Research, 1982).

[17] In constructing this explanatory variable, we first calculated the share of each importer's tradable expenditures going to each trading partner's exports in each product group of each industry. This ratio can be shown to represent the relative importance in each importer's utility of each trading partner's exports in each product class. Second, we calculated the difference between this ratio and the simple average of the ratios for all importers. This difference reflects the dissimilarity of each importer's tastes for an exporter's product from the average for all importers. Third, each (squared) difference was weighted by the share of trade in an industry between two countries in that product group. A high value for the variable reflects that trade between two countries in a particular industry is dominated by product groups where tastes of the respective countries differ strongly from the norm.

industry, as measured by a higher degree of increasing returns, the greater the degree of IIT, as expected. Second, the lower the degree of tariff and nontariff protection, the greater is the degree of IIT. This result is consistent with the explanation that trade liberalization increases intra-industry specialization in differentiated products.

Third, as trade is increasingly dominated by product groups using widely different combinations of productive resources, the degree of IIT falls. That is, as trade is composed more of product classes of widely different production methods, the share of trade that is inter-industry in character increases, as expected. Fourth, both border trade and taste differences are not as important in causing IIT as the other variables.

## *Part III. Concluding Remarks*

This study has attempted to respond to three major questions that have arisen subsequent to the observance of IIT: Is IIT scant or widespread? Does it have a diminishing or growing role in trade between nations? What causes similar nations to trade in similar products?

IIT was found to be prominent in trade among numerous pairs of industrialized countries, using trade data for industries composing an industry group highly representative of all manufactures. A new index of IIT was introduced and used to demonstrate that the usual measure tends to understate the degree of IIT relative to the new measure. Moreover, IIT — measured by either index — has grown substantially over the period 1965 to 1976. The extent and growth of trade overlap do not imply the need for a new theory to replace the principle of comparative advantage in order to explain why industrialized nations trade. Indeed, a theory of IIT in differentiated products forms a perfect complement to comparative advantage, the principle underlying traditional theories of inter-industry trade.

In traditional trade theories, products of the same industry regardless of the country of origin are viewed by consumers as perfect substitutes; in the IIT model, all products of the same industry are slightly differentiated. In traditional theories, goods are produced under constant returns to scale; in the IIT model, goods are produced under initially increasing (and eventually decreasing) returns to scale. In traditional theories, gains from trade arise from exploitation of innate differences in relative unit production costs. In the IIT theory, countries possess no innate differences; comparative advantages are "acquired" as firms specialize in response to consumers' tastes for diversity, realizing increasing returns in the production of uniquely differentiated goods. In the absence of innate production differences, IIT theory explains why nations trade but cannot predict which country will export which products.

The results of our statistical investigation yielded five interesting conclusions. First, IIT does *not* appear to be merely an arbitrary consequence of aggregation of products of essentially different industries. Second, IIT increases when pairs of countries specialize so as to exploit economies of scale in their bilateral trade. Third, greater product differentiation in trade between pairs of 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 trade that is intra-industry, and decrease the share that is inter-industry, in character. 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 productive factors are correspondingly low.

## APPENDIX

### THE ECONOMETRIC MODEL

The regression equations estimated in Part II are based upon the following methodology. The dependent variable in all regressions is a logit transformation of the IIT index. A pure IIT index as the dependent variable in a regression yields biased coefficient estimates. This results from truncations of the continuous distribution at 0 and 1. A logit transformation of the $IIT_{ij}^{k}$ index, $LIIT_{ij}^{k}$, where:

$$(B1)\ LIIT_{ij}^{k} = \ln[IIT_{ij}^{k}/(1 - IIT_{ij}^{k})]$$

maps (monotonically) values between 0 and 1 in the observed distribution onto a continuous distribution ranging from $-\infty$ to $\infty$. The logit of the IIT index will yield unbiased coefficient estimates in regressions.[1] All independent variables in regressions (except adjacency dummy, SITC 71 dummy, and SITC 73 dummy) are expressed in natural logarithms, so that coefficient estimates are elasticities. Independent variables are the same in all regressions, except for whether actual or trade-balanced trade flows are used in their construction (in this appendix, construction of all independent variables is shown using actual trade flows).

For econometric purposes, all regressions are estimated using weighted least squares. Although the logit of the IIT index yields

[1] See, for example, H. Theil, *Principles of Econometrics* (New York: John Wiley and Sons, 1971), pp. 628–636.

unbiased estimates, it can be shown that ordinary least squares (OLS) suggests $E(u^k_{ij}) = 0$ but $Var(u^k_{ij}) = \sigma^2/[IIT^k_{ij}(1 - IIT^k_{ij})]$, where $u^k_{ij}$ is the error term in an OLS regression of the logit of IIT on a vector of independent variables (assuming $IIT^k_{ij}$ is drawn from a sample of one). To eliminate heteroskedasticity, the dependent and independent variables are first weighted by $\sqrt{IIT^k_{ij}(1 - IIT^k_{ij})}$, then least squares is performed. In Tables 5 and 6, "quasi-constant" reflects the constant term being replaced by $\sqrt{IIT^k_{ij}(1 - IIT^k_{ij})}$ in the regression as a consequence of the transformation. We now define the independent variables.

**Increasing Returns/Product Differentiation (IR)**

This variable measures the extent to which a pair of countries are trading more widely differentiated products, produced at a higher "elasticity of scale." First, we measure the degree of increasing returns (measured by the elasticity of scale) for product classes composing 2-digit SITC industries in SITC 7. Second, we construct the increasing returns variable using these elasticity of scale estimates.

The elasticity of scale is defined as the percentage increase in output per worker (decrease in unit production cost) as all inputs are doubled. A common method for calculating the elasticity of scale for several product classes is to estimate the following regression across plant size in each product class:

$$(B2)\quad V_g = \alpha(Z_g)^\beta$$

where $V_g$ is the adjusted value added per worker in plant size class g, $Z_g$ is the average number of workers employed per plant in plant size class g, $\alpha$ is a constant, and $\beta$ is the elasticity of scale.[2] Adjusted value added in a particular plant size class is assumed proportional to total output.

The 1977 U.S. *Census of Manufactures* provides value added data at the 4-digit U.S. Standard Industrial Classification (SIC) level disaggregated across various plant size classes. The 4-digit U.S. SIC level is the highest level of disaggregation 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 their value addeds were "adjusted" for differences across 4-digit SICs unrelated to scale of production. Elasticities of scale are estimated for each of the 18 3-digit SITCs in SITC 7 and estimates are presented in Table 4. The estimates generally suggest statistically significant initially increasing returns to larger plant size for product classes in SITC 7. The mean value of 0.05 implies that long-run average costs fall by 5 percent, on average, as plant size doubles.

The independent variable representing the degree of increasing returns (or product differentiation) implicit in the trade between pairs of countries ($IR^k_{ij}$) is now calculated. For countries i and j in each industry k, each 3-digit SITC elasticity of scale estimate is weighted by the share of trade between i and j in that 3-digit product class out of total trade between i and j in 2-digit industry k. Formally:

$$(B3)\quad IR^k_{ij} = \sum_{\ell=1}^{L} [(X^{k\ell}_{ij} + X^{k\ell}_{ji})/(X^k_{ij} + X^k_{ji})]\, ES^{k\ell}$$

where $X^{k\ell}_{ij}$ ($X^{k\ell}_{ji}$) is the trade flow from country i to country j (j to i) of product class $\ell$ in industry k, $X^k_{ij}$ ($X^k_{ji}$) is the trade flow from country i to country j (j to i) in industry k, and $ES^{k\ell}$ is the U.S. elasticity of scale estimate for product class $\ell$ in industry k. By using only U.S. estimates of elasticities of scale, a restriction of identical technologies is imposed across countries. Given the long-run equilibrium condition that the elasticity of scale and degree of product differentiation are positively related, a higher value for this variable implies two countries are trading more widely differentiated products (see text footnote 15). Hence, the degree of IIT should be higher.

**Effective Tariff and Nontariff Protection (TAR)**

The influence on the degree of IIT of effective tariff and nontariff protection is captured by a proxy — nominal tariff rates. High correlation coefficients between industries' effective tariff and nontariff rates of protection and their nominal tariff rates suggest that the latter is an apt proxy for the former.[3]

The GATT's *Basic Documentation for Tariff Study* (1970) provides nominal tariff data for 14 major industrialized countries (the reason for the countries chosen in this study) disaggregated by product category. In SITC 7, GATT product categories are comparable to 2-digit SITC levels (SITCs 71, 72, 73). Like the increasing returns variable, tariff data availability limits disaggregation in the regression analysis to the 2-digit SITC level.

For every pair of countries, the tariff variable ($TAR^k_{ij}$) is the simple average of the two countries' nominal tariff rates in industry

[2] This method was used in G.C. Hufbauer, "The Impact of National Characteristics and Technology on the Commodity Composition of Trade in Manufactured Goods," in R. Vernon, *The Technology Factor in International Trade* (New York: National Bureau of Economic Research, 1970).

[3] Robert E. Baldwin, *Nontariff Distortions of International Trade* (Washington, D.C.: Brookings Institution, 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. For the United States, 1972 data were from Table 4's columns (2) and (4) in Baldwin. For the United Kingdom, 1972 data were from columns (2) and (5) in Table 6.

**Table 4**
**Parameter Estimates of the Elasticity of Scale for All 3-Digit SITC Product Classes in SITC 7***

| SITC | Elasticity est. | (t-stat) | n | SITC | Elasticity est. | (t-stat) | n | SITC | Elasticity 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 | .0536[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: U.S. Bureau of the Census, *Census of Manufactures*, 1977.

k.[4] 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 EFTA, or one is in the EC and other in EFTA.

### Border Trade (DIST and ADJ)

Two variables attempt to explain border trade. Distance ($DIST_{ij}$) between economic centers of countries i and j is a proxy for transport costs. The adjacency variable ($ADJ_{ij}$) captures special economic relations between neighbors. ADJ assumes a value of one when two countries have a common land border, and zero otherwise.

### Relative Factor Intensity Differences within Industries (KL)

This variable is formally defined as:

$$\text{(B4)}\quad KL_{ij}^{k} = \sum_{\ell=1}^{L} [(X_{ij}^{k\ell} + X_{ji}^{k\ell})/(X_{ij}^{k} + X_{ji}^{k})][(K/L)^{k\ell} - \overline{(K/L)}^{k}]^2$$

where $X_{ij}^{k\ell}$, $X_{ji}^{k\ell}$, $X_{ij}^{k}$, and $X_{ji}^{k}$ are defined earlier, $(K/L)^{k\ell}$ is the U.S. capital-labor (K-L) input ratio for the $\ell^{th}$ 3-digit SITC product class, and $\overline{(K/L)}^{k}$ is the mean of all 3-digit K-L ratios in the $k^{th}$ 2-digit SITC industry.

A high value for KL implies that trade between countries i and j in industry k is comprised largely of product classes of widely different relative factor intensities. Hence, trade should be more inter-industry and less intra-industry in character.

### Taste Differences (TASD)

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:

$$\text{(B5)}\quad U_j = [\sum_{i \neq j}^{I} \sum_{\ell}^{L} a_{ij\ell} X_{ij\ell}^{\theta}]^{\frac{1}{\theta}}$$

where $a_{ij\ell}$ is the importance in country j's utility of country i's exports in product class $\ell$, $X_{ij\ell}$ is country j's imports from country i in product class $\ell$, and $\theta$ 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:

$$\text{(B6)}\quad \sum_{i \neq j}^{I} \sum_{\ell}^{L} p_{ij\ell} X_{ij\ell} = Y_j^T$$

where $p_{ij\ell}$ is the price of country i's exports to j in product class $\ell$, and $Y_j^T$ is tradable expenditures of country j. Maximizing equation (B5) subject to equation (B6) and solving the first order conditions for $X_{ij\ell}/Y_j^T$ yields:

$$\text{(B7)}\quad x_{ij}^{k\ell} = X_{ij\ell}/Y_j^T = \frac{p_{ij\ell}^{-\rho} a_{ij\ell}^{\rho}}{\sum_{i \neq j}^{I} \sum_{\ell}^{L} p_{ij\ell}^{1-\rho} a_{ij\ell}^{\rho}}$$

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

$$\text{(B8)}\quad x_{ij}^{k\ell} - \bar{x}_{i\cdot}^{k\ell} = p_{\ell}^{\rho}\left[\frac{a_{ij\ell}^{\rho}}{\sum_{i \neq j} \sum_{\ell} p_{\ell}^{1-\rho} a_{ij\ell}^{\rho}} - \frac{1}{I} \sum_{j=1}^{I} \frac{a_{ij\ell}^{\rho}}{\sum_{i \neq j} \sum_{\ell} p_{\ell}^{1-\rho} a_{ij\ell}^{\rho}}\right]$$

where $p_{ij\ell} = p_{\ell}$ (for all $i \neq j$) by the assumption of perfect commodity arbitrage and $\bar{x}_{i\cdot}^{k\ell}$ is the mean of $x_{ij}^{k\ell}$ 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:

$$TASD_{ij}^{k} = \tfrac{1}{2} \sum_{\ell=1}^{L} [(X_{ij}^{k\ell}/X_{ij}^{k})(x_{ij}^{k\ell} - \bar{x}_{i\cdot}^{k\ell})^2 + (X_{ji}^{k\ell}/X_{ji}^{k})(x_{ji}^{k\ell} - \bar{x}_{j\cdot}^{k\ell})^2]$$

where $X_{ij}^{k\ell}$, $X_{ji}^{k\ell}$, $X_{ij}^{k}$ and $X_{ji}^{k}$ are defined earlier and $(x_{ji}^{k\ell} - \bar{x}_{j\cdot}^{k\ell})$ is constructed for country i in the same manner as in equations (B7) and (B8).

### SITC 71 and 73 (first three regressions only)

Because the average level of IIT differs across industries for unrelated reasons, dummy variables are introduced when SITCs 71, 72, and 73 are pooled for the first three regressions. The variable SITC 71 (73) assumes a value of one when each observation is for SITC 71 (73), and zero otherwise.

## ESTIMATION RESULTS

Initially, three regressions are estimated. In the first regression, the IIT index is calculated as in equation (1) using actual trade flows for bilateral trade among the same 14 OECD countries mentioned earlier. The dependent variable is calculated using these indexes for all 2-digit SITC industries (71, 72, 73) composing SITC 7. Due to data constraints on formulating several independent variables, the 2-digit SITC level is considered an industry. However, the third regression tests for the restrictiveness of this assumption. To expand the power of the regressions, cross-country IIT observations for all three industries are pooled. However, dummy variables (SITC 71 and 73) are introduced to account for differences across industries in the average level of IIT, owing to innate differences in the "nature" of the industry or goods in the industry (e.g., transportability of industry output, market structure, etc.).

In the second regression, trade-balanced trade flows are substituted for actual trade flows in calculating the IIT index (TB - IIT). When appropriate, independent variables are constructed using trade-balanced trade flows also. In all other respects, the dependent variable is the same as in the first regression.

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 aver-

---

[4] 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). Regression estimation using TAR2 rather than a simple average of $t_i^{k}$ and $t_j^{k}$ yields no noticeably different results.

Table 5
Regression Results Using Alternative IIT Indexes as the 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.

age, TB-IIT). The dependent variable is the weighted logit of the following IIT index:

$$AIIT_{ij}^{k*} = 1 - \frac{1}{L} \sum_{\ell=1}^{L} [\,|X_{ij}^{k\ell*} - X_{ji}^{k\ell*}|/(X_{ij}^{k\ell*} + X_{ji}^{k\ell*})]$$

where $X_{ij}^{k\ell*}$ ($X_{ji}^{k\ell*}$) is the value of the trade-balanced trade flow from country i to country j (j to i) in product class $\ell$ of industry k. Due to resource constraints, this alternative index is calculated using 1976 trade flows, unlike the previous two indexes which use flows averaged over 1975–1977.

Table 5 presents the results of the first three regressions. In general, results from the regressions are similar, although certain independent variables are statistically significant in the latter two regressions — using trade-balanced flows — that are not significant in the first regression. First, a higher degree of increasing returns, implying greater product differentiation, in trade between two countries in an industry increases the degree of IIT. The lower the effective degree of tariff and nontariff protection, the greater is the degree of IIT. Border trade does not appear to be a quantitatively important source of IIT. Distance's coefficient is significant sometimes, but adjacency has the correct sign in only the third regression. As trade is dominated by product classes of widely different relative factor intensities, the degree of inter-industry trade rises, as expected, and the degree of IIT falls. Only in regressions using trade-balanced trade flows do taste differences significantly influence IIT (statistically significant positive coefficients).

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

To illustrate that the specifications in Table 5 are appropriate and estimated effects are *not* very restricted, the three specifications were estimated separately for each industry. For brevity, results are presented only for the specification using an average of 3-digit SITC indexes constructed from trade-balanced trade flows for the dependent variable (specification [3]). Results for the other two specifications are very similar but slightly less robust. The results are presented in Table 6.

In general, coefficient estimate signs do not vary much across industries and are similar to those in Regression (3). Most important, coefficient estimates for the increasing returns variable are generally stable across industries and are statistically significant in two of the three regressions. We also calculated formal F-tests of equality of coefficient estimates across industries; results were mixed. For specification (1), an F-statistic of 2.326 indicated that equality could be rejected at the 1 percent significance level, but could not be rejected at the 0.5 percent significance level. For specification (2), an F-statistic of 2.596 indicated that equality could be rejected at the 1 percent significance level, but could not be rejected at the 0.1 percent significance level. For specification (3), an F-statistic of 4.327 indicated that equality could be rejected at the 0.1 percent significance level.

Table 6
Regression Results by Individual Industries Composing SITC 7, Machinery and Transport Equipment

| Variables | Expected Coefficient Estimate Signs | Regressions (4) SITC 71 | (5) SITC 72 | (6) SITC 73 |
|---|---|---|---|---|
| Increasing Returns/Product Differentiation | + | 0.802[a] (1.530) | 0.855 (1.021) | 0.543[b] (1.732) |
| Tariff | − | −0.089[b] (2.296) | −0.043 (1.215) | 0.010 (0.223) |
| Distance | − | 0.027 (0.203) | −0.129 (0.973) | −0.340[c] (2.356) |
| Adjacency | + | 0.106 (0.465) | 0.174 (0.764) | 0.200 (0.875) |
| Factor Intensity Differences | − | −0.168 (1.017) | −0.031 (0.222) | −0.163 (0.353) |
| Taste Differences | + | 0.052 (1.187) | 0.086[b] (1.873) | 0.021 (0.563) |
| Quasi-Constant | na | −0.330 (0.107) | −1.142 (0.256) | 2.479 (0.375) |
| Number of Observations | | 91 | 91 | 91 |
| F-statistic | | 3.933* | 5.091* | 12.093* |

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.

## Simulating Bilateral Disaggregate Trade Flows to Reflect Multilateral Aggregate Trade Balance

Since David Ricardo's time, the pure theory of international trade has assumed each country's aggregate trade is multilaterally balanced. As merchandise trade dominates international transactions, multilateral aggregate trade balance suggests balance of payments factors can be ignored. Formally, the alternative IIT index is:

$$(2)\quad IIT_{ij}^{k^*} = 1 - [|X_{ij}^{k^*} - X_{ji}^{k^*}| / (X_{ij}^{k^*} + X_{ji}^{k^*})]$$

where

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

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

and

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

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

and $X_{ij}^k$ ($X_{ji}^k$) is the value of the actual trade flow in industry k from country i to country j (j to i). Computing $X_{ij}^{k^*}$ ($X_{ji}^{k^*}$) iteratively until some convergence criterion is met (e.g., $[(X_{ij}^{k^*})_t - (X_{ij}^{k^*})_{t-1}]/(X_{ij}^{k^*})_{t-1} \le 0.001$) yields bilateral trade flows for the $k^{th}$ industry that are simulated to reflect multilateral aggregate trade balance.

Because the problem addresses multilateral aggregate trade balance for bilateral disaggregate trade flows, an example necessitates at least three countries (1, 2, 3) and two goods (A, B). Let the bilateral trade flows for each good be represented as follows:

A

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

B

| | | 1 | 2 | 3 | |
|---|---|---|---|---|---|
| Exporter | 1 | 0 | 10 | 10 | 20 |
| | 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 (2) 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).