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The Determinants of Intra-Industry Specialization
in United States Trade

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The views presented here are those of the author, and they should not be interpreted as reflecting those of the World Bank.
Abstract

This paper set out to explain the determinants of intra-industry specialization in the United States by reference to industry as well as country characteristics. It is shown that the extent of intra-industry trade is positively correlated with product differentiation, marketing costs, the variability of profit rates, and offshore procurement, and it is negatively correlated with economies of scale, industrial concentration, foreign direct investment, and transportation costs. It is further shown that intra-industry specialization in U.S. trade with individual countries is positively correlated with the extent of trade orientation in those countries and it is negatively correlated with inequalities in per capita incomes and total GNP and with distance between the U.S. and the individual countries.
THE DETERMINANTS OF INTRA-INDUSTRY SPECIALIZATION
IN UNITED STATES TRADE

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June 1984

* Professor of Political Economy at the Johns Hopkins University and Consultant to the World Bank. This paper was prepared in the framework of the World Bank's research project, "Changes in Comparative Advantage in Manufactured Goods" (RPO 672-41). The author is greatly indebted to Marcus Noland for reviewing alternative explanatory variables and suggesting possible specifications and to Luc Bauwens for undertaking the arduous task of estimation and offering valuable comments on the previous draft of the paper. Thanks are also due to Linda Pacheco for data collection and to Jerzy Rozanski for generating the trade data. However, the author alone is responsible for the opinions expressed in the paper that should not be interpreted to represent the views of the World Bank.
THE DETERMINANTS OF INTRA-INDUSTRY SPECIALIZATION IN UNITED STATES TRADE

Bela Balassa

In recent years a number of studies investigated the determinants of intra-industry trade. 1/ Several authors set out to explain interindustry differences in the extent of such trade by the use of data for the United States (Pagoulatos and Sorensen, 1975 and Toh, 1982), for Sweden (Lundberg, 1982), and for the industrial countries, on the average (Caves, 1981). In turn, others analyzed intercountry differences in the extent of intra-industry trade (Loertscher and Wolter, 1980, Bergstrand, 1983, Havrylyshyn and Civan, 1983, and Balassa, 1984a and b, and Clair, Gaussens, and Phan 1984).

The present paper combines these approaches in examining the determinants of intra-industry specialization in United States trade by reference to industry as well as country characteristics. 2/ In so doing, use has been made of the industry variables introduced by Caves, who provides the most sophisticated analysis of interindustry differences in the extent of intra-industry trade, 3/ with the addition of variables for industrial concentration and off-shore procurement. Furthermore, country variables have been introduced, so as to consider simultaneously the interindustry and the intercountry determinants of intra-industry specialization.

1/ The expressions "intra-industry specialization" and "intra-industry trade" are used interchangeably in the paper.

2/ Loertscher and Wolter also attempted to simultaneously explain differences in the extent of intra-industry trade among industries and among countries. While the regression coefficients of several of the variables pertaining to interindustry and intercountry differences in intra-industry trade were statistically significant, the coefficient of determination was only 0.07.

3/ The author is indebted to Professor Caves for providing the relevant data.
Section I describes the commodity and the country characteristics used in the estimates and the methodology employed. Sections II and III, respectively, review the interindustry and intercountry determinants of the extent of intra-industry trade. The empirical results are presented in Section IV.

I

The investigation pertains to manufactured goods, with the exclusion of natural resource products whose manufacture is importantly affected by the availability of natural resources in a particular country. The commodity classification scheme utilized has been established on the basis of the United States Standard Industrial Classification, with 4-digit SITC categories merged in cases when the economic characteristics of particular products have been judged to be very similar. The application of this procedure has led to the choice of altogether 167 industry categories that have been matched with the 3- and 4-digit categories of the UN Standard International Trade Classification (SITC). 1/ The use of an economically meaningful classification scheme is of importance, so as to identify "genuine" as

1/ The investigation excludes foods and beverages (SIC 20), tobacco (SIC 21), non-ferrous metals (SIC 333), as well as several 4-digit categories covering textile waste, preserved wood, saw mill products, prefabricated wood, veneer and plywood, wood pulp, dyeing and tanning extracts, fertilizers, adhesives and gelatin, carbon black, petroleum refining and products, asbestos and asphalt products, cement and concrete, lime, gypsum products, cut stone products, and lapidary work. It also excludes ordnance (SIC 19), for which comparable trade data are not available.
compared to spurious intra-industry trade, which latter is an artifact of the classification scheme employed. 1/

The investigation covers 38 countries, each of which had manufactured exports of at least $300 million, accounting for 18 percent or more of total exports, in 1979. Data on U.S. trade in a particular industry with a particular country have been taken as the unit of observation.

The formula utilized in deriving the index of intra-industry trade (IIT) is shown in equation (1) that makes adjustment for imbalance in the total trade of the United States with individual countries. 2/

\[
IIT_{ji} = 1 - \frac{|X_{ji}^e - M_{ji}^e|}{X_{ji}^e + M_{ji}^e} = 1 - \frac{|X_{ji}^e - M_{ji}^e|}{X_{ji}^e + M_{ji}^e}
\]

1/ By contrast, Pagoulatos and Sorensen (1975) and Havrylyshyn and Civan (1983) used 102 3-digit SITC categories; Loertscher and Wolter selected 59 such categories because of a lack of sufficient reliable exogenous data (1980, p. 285n) for others; Caves (1981) chose 84 3-digit SITC categories which could be identified with 4-digit SIC categories; Toh utilized 112 4-digit SIC categories for which comparable trade data could be "derived from aggregating comparable and not too many SITC numbers in order to keep the extent of statistical aggregation bias to the minimum" (1982, p. 288); and Lundberg (1983) made calculations for the 77 manufacturing sectors of the International Standard Industrial Classification. None of these authors attempted to combine the statistical categories or to exclude natural-resource products. In turn, several of them introduced variables to evaluate the implications for the index of intra-industry trade of the heterogeneity of the statistical categories that is not necessary if an economically meaningful system of classification is used.

2/ For reasons first explained in Balassa 1979, a modified form of the Aquino (1978) adjustment has been used in defining the index of intra-industry trade.
where \( X^e_{ji} = X_{ji} \frac{X_j + M_j}{2X_j} \) and \( M^e_{ji} = M_{ji} \frac{X_j + M_j}{2M_j} \).

The index of intra-industry trade takes values from 0 to 1 as the extent of intra-industry trade increases. However, if estimation is made by using a linear or loglinear function, the predicted values may exceed one; they may also be negative if the regression equation is linear. In turn, with a logistic function and its logit transformation, the predicted values are always between 0 and 1.

A linear regression equation was estimated by ordinary least squares by all the authors cited, except for Pagoulatos and Sorensen (1975) who estimated a loglinear function, and Loertscher and Wolter (1980) who estimated a logit transformation by weighted least squares, so as to eliminate a potential source of heteroscedasticity. The latter method was also used by Caves.

The adjustment for heteroscedasticity is justified by the authors by reference to the minimum chi-square estimation of the logit model in the case of multiple observations. Following Maddala (1983, section 2.8), suppose \( IIT_{ji} \), in equation (2) is obtained as \( m_{ji} / n_{ji} \), where \( n_{ji} \) is the number of observations corresponding to \( z_{ji} \) and \( m_{ji} \) the number "successes," i.e. of occurrences of some event; then if \( n_{ji} \) is large, the residual \( u_{ji} \) of equation (2) has approximately a variance of \( \sigma^2 w^2_{ji} \), where \( w^2_{ji} = 1/n_{ji} IIT_{ji} (1-IIT_{ji}) \). In the equation, \( z_{ji} \) is the vector

\[
(2) \quad \ln \frac{IIT_{ji}}{1-IIT_{ji}} = \beta z_{ji} + u_{ji}
\]
of explanatory variables (including a constant), $\beta$ the corresponding vector of coefficients, $j$ refers to country characteristics and $i$ pertains to industry characteristics.

The correct estimation procedure involves multiplying the dependent variable as well as each of the explanatory variables by the adjustment factor $\sqrt{n_{ji} IIT_{ji}(1-IIT_{ji})}$, with ordinary least squares applied to the transformed variables. Loerstcher and Wolter appropriately weighted the explanatory variables but neglected to weight the dependent variable. $^1$ In turn, as noted by Bergstrand (1983), Caves divided rather than multiplied the dependent and the explanatory variables by the adjustment factor. $^2$

The experience of the present study indicates that the use of the wrong adjustment procedure may affect the results to a considerable extent. Thus, dividing instead of multiplying the dependent and the explanatory variables by the adjustment factor $\sqrt{IIT_{ji}(1-IIT_{ji})}$ has reduced the number of variables with a $t$-value of 2.5 or higher from fourteen to two. Also, the coefficient of determination has declined from 0.87 to 0.10 $^3$ (Table 1).

$^1$ As explained in the Appendix to Balassa (1984b) by Luc Bauwens, this error is likely to distort their results considerably. Note that these authors assumed that $n_{ji} = 1$ in the adjustment factor.

$^2$ Caves uses the total size of the U.S. industry, measured by value added, instead of $n_{ji}$ in the adjustment factor.

$^3$ This is not to imply that similar differences would arise in regard to Caves' results. The more extreme values of $IIT_{ji}$ there are in the sample, the more the results can be expected to differ, not only between incorrect or correct weighted least squares, but even between any of these methods and ordinary least squares applied to (2). The range of Caves' data is .25 to .82 (with only 7 observations on 84 outside the range .40 to .82), while in the present study the range is 0. to 0.99.
Further questions arise about the appropriateness of the adjustment procedure. The definition of $\text{IIT}_{ji}$ given in formula (1) does not match its interpretation as a proportion $m_{ji}/n_{ji}$ of "successes" in a sequence of independent Bernouilli trials that is required to justify this kind of adjustment for heteroscedasticity. Nor do Loerstcher and Wolter, Caves and Bergstrand (1983) provide any justification for such an interpretation, although they use the adjustment procedure. At the same time, estimation in the present case does not furnish evidence of this kind of heteroscedasticity. 1/

Also, while the logit transformation has the advantage of ensuring that predicted values are within the appropriate range, it has the disadvantage of excluding all observations where the index of intra-industry trade takes values of 0 or 1. While none of the indices are equal to one in the present case, nearly one-third of the observations equal zero, indicating the absence of intra-industry trade. Zero observations occur if there are U.S. exports of commodity $i$ in trade with country $j$ but no corresponding imports (27.1 percent of the observations) or if there are U.S. imports but no exports (4.3 percent). 2/

In view of the questions raised about the appropriateness of the weighting procedure and the omission of all zero observations, it would be desirable to utilize an alternative procedure that is not subject to these shortcomings while it ensures that the predicted values of the index of intra-

1/ I am indebted to Luc Bauwens on this point.

2/ Note that in cases where there are neither exports nor imports (5.9 percent of the observations) the index of intra-industry trade is not defined, and the observations have been excluded from the statistical analysis.
industry trade takes values between 0 and 1. These conditions are fulfilled in the case of nonlinear least squares estimation of equation (3). In the present study, estimates have been made including as well as excluding zero observations, so as to permit comparisons with the results obtained by weighted least squares.

\[
(3) \quad IIT_{ji} = \frac{1}{1 + e^{-\beta z_{ji}}} + \varepsilon_{ji}
\]

II

In the following, consideration will first be given to the factors that determine the extent of intra-industry trade in an interindustry context. Linder (1961) and Dreze (1960) were the first to emphasize the importance of product differentiation in international trade. In the theoretical models of Krugman (1979, 1980), Lancaster (1980) and Helpman (1981), product differentiation is taken to be a precondition of intra-industry specialization. In fact, apart from seasonal and border trade, intra-industry trade is not expected to occur in standardized commodities. 1/

Hufbauer (1970) used the coefficient of variation of export unit values as a measure of product differentiation on the assumption that an inverse relationship exists between the degree of product standardization and the dispersion of prices within each category. While Gray and Martin (1980) criticized this procedure on the grounds that unit values do not appropriately represent prices, at the 7-digit level of the SITC classification utilized by

1/ However, Brander (1981) considers the case of intra-industry trade in standardized commodities under conditions of Cournot-type duopoly.
Hufbauer differences in unit values will largely reflect differences in product characteristics. At any rate, for lack of price observations in the necessary detail, the hedonic price indices suggested by Gray and Martin are not practicable. Consequently, following Caves (1981) and Toh (1982), use has been made of the Hufbauer measure of product differentiation in the present investigation.

Caves utilized Hufbauer's measure of product differentiation along with other indicators arranged on a scale, reflecting the assumption that "complexity" would favor international trade and "information" would discourage it. In descending order, following Hufbauer's proxy for product differentiation, the variables are research and development as a percentage of sales, selling costs as a percentage of total costs; marketing, planning, and support costs as a percentage of total costs; and advertising expenditures as a percentage of sales.

Caves also includes foreign direct investment under this heading on the grounds that it indicates the opportunities created by product differentiation to serve foreign markets by local production rather than by exports. But this variable also has dimensions other than product differentiation and will be considered separately below. In turn, one may regard the standard deviation of profit rates, used by Caves to indicate the heterogeneity of individual commodity categories, as a measure of product differentiation.

Theorists of intra-industry trade hold that economies of scale are a sine qua non of intra-industry specialization; in the absence of scale economies, all product varieties could be produced domestically and no intra-industry trade would take place. Various measures were employed as proxies
for economies of scale in empirical investigations of intra-industry trade. Hufbauer regressed value added per man on firm size measured in terms of employment; Loertscher and Wolter used average value added per establishment; Caves divided minimum plant size by a measure of the cost disadvantages of small firms; and Lundberg utilized the share of labor force in firms having more than 500 workers for this purpose.

All these measures relate costs to plant size. This is not the relevant consideration, however, regarding economies of scale in industries producing differentiated products, which are characterized by horizontal and vertical specialization. The former involves lessening product variety in individual plants while the latter entails producing parts, components, and accessories of a particular product in different plants. Now, vertical specialization and, to a lesser extent, horizontal specialization, may involve reducing rather than increasing plant size. 1/

Correspondingly, the above measures will reflect the relative importance of product standardization and hence are expected to be negatively correlated with the extent of intra-industry trade. 2/ In the present investigation, use has been made of Caves' measure of economies of scale (ECSC). This involves dividing the ratio of the average size of the largest plants in U.S. industry, accounting for approximately one-half of industry shipments, to total industry shipment by the ratio of value added per worker

1/ These concepts were first introduced in Balassa, 1967.

2/ Caves also expects a negative sign for this variable on the grounds that extensive scale economies would confine production to a few locations. This notion again pertains to standardized rather than to differentiated products.
in the smaller plants, again accounting for one-half of industry shipments, to value added per worker in the larger plants.

In turn, Toh suggested defining the length of the production run, associated with reductions in product variety, as the ratio of expenditures on new machinery to the capitalized value of the difference between the average wage and the unskilled wage. However, this measure indicates the relative physical capital intensity of the production process rather than the length of the production run. At any rate, the use of this variable has not given statistically significant results in the present investigation and it has been excluded from the estimating equations reported in Table 1.

Product standardization is further related to the extent of industrial concentration; ceteris paribus, the possibilities for concentration can be expected to decline with the differentiation of the product. 1/ It can thus be hypothesized that intra-industry trade will be negatively associated with industrial concentration. This hypothesis has been tested by utilizing the internationally adjusted concentration ratio (IACR) introduced by Toh that adjusts for the extent of competition from abroad. It is derived by dividing the traditional concentration ratio (the share of the largest four firms in the industry's output) by the share of imports in the industry's output. 2/

The author suggested nearly two decades ago that, as the size of the foreign market increases, exports will give place to foreign direct investment

1/ As Eastman and Stykolt note, a different conclusion would be reached if product differentiation raised entry barriers (1967, Ch. 1). For further discussion, see Caves, Porter, Spence, and Scott (1980, p. 44).

2/ The explanation given by Toh for the negative sign he obtains is couched in terms of oligopolistic interdependence without reference to differences between industries producing standardized and differentiated products.
by oligopolistic firms that wish to exploit the possibilities inherent in the differential characteristics of their products (Balassa, 1966).

Correspondingly, it can be hypothesized that the extent of intra-industry trade will be negatively correlated with foreign direct investment (FDI). In turn, Caves suggests that a positive correlation is expected with the extent of trade with foreign affiliates (AFFL) that may involve the exchange of parts, components, accessories, as well as of differentiated products.

Krugman (1980) showed that, in a model of product differentiation under economies of scale, with trade taking place between two identical countries, the introduction of transportation costs will not affect the number of firms or the output of individual firms in either country. Nevertheless, transportation costs will raise the prices of imported goods, relative to the prices of domestic goods in both countries, thus resulting in a decline in the volume of intra-industry trade. Correspondingly, it can be hypothesized that the extent of intra-industry trade will be negatively correlated with transportation costs.

Transportation costs have been proxied by the mean distance of shipments within the United States in all the empirical studies cited, except that Lundberg does not use such a variable. This procedure has the double shortcoming of equating transportation costs to distance and using distance for inland transportation in a single country in the place of international transportation that tends to take the sea route. In the present investigation, use has been made of a model developed by Lipsey and Weiss

1/ Intra-European trade provides only a partial exception as the low cost of sea shipping has led to its extensive use among European countries.
(1974) in expressing transportation costs as a function of product unit value, stowage, and dummy variables for low-weight products as well as for the use of tankers.

In their investigation of intra-industry trade, Pagoulatos and Sorensen included the average height of tariff and of non-tariff barriers, as well as their dispersion, among the explanatory variables on the assumption that both the height and the variability of protection limit the extent of intra-industry trade. However, as Caves notes, theoretical considerations do not lead to a definite hypothesis in regard to inter-industry differences in protection levels and increasing the variance of protection rates may reduce rather than increase the extent of intra-industry trade under plausible assumptions. In the present investigation, none of these variables has given statistically significant results at even the 10 percent level and they have been omitted from the estimating equations reported in Table 1.

Finally, offshore assembly provisions (OAP) may lead to increased intra-industry trade by encouraging the international division of the production process, involving vertical specialization. Correspondingly, a negative correlation is hypothesized between the two variables.

III

We come next to the factors that determine the extent of intra-industry trade in an intercountry context. Linder advanced the hypothesis that the extent of trade in differentiated products will be the greater, the more similar are income levels among the trading countries. This hypothesis reflects the assumption that similarities in income levels are associated with similarities in demand structures that, in turn, provide the basis for mutual trade in differentiated products (1961, p. 94). Subsequently, Helpman
provided proof of the proposition that the extent of intra-industry trade will be the greater the more similar are the capital-labor ratios of the trading partners and suggested testing this proposition by taking per capita incomes as a proxy for capital-labor ratios (1981, pp. 325,337).

Helpman also provided proof for the proposition that the extent of intra-industry trade will be the greater, the more similar is the size of the trading partners (Ibid, p. 327). This proposition can be expressed in the form of a testable hypothesis that the extent of intra-industry trade is negatively correlated with intercountry differences in regard to the gross national product, taken to be a measure of market size.

These two hypotheses have been tested in the present investigation for the trade of the United States with individual countries by the use of an inequality measure that takes values between 0 and 1. 1/ This measure is defined in equation (4) where \( w \) refers to the ratio of the particular characteristic in country \( j \) to the sum of this characteristic in country \( j \) and in partner country \( k \). 2/

\[
(4) \quad \text{INEQ} = 1 + \left[ w \ln(w) + (1 - w)\ln(1 - w) \right]/\ln 2
\]

1/ Loertscher and Wolter tested these hypotheses in regard to the mutual trade of the industrial countries by using intercountry differences in per capita GDP and in GDP as explanatory variables.

2/ The use of this measure has been proposed by Roger Bowden.
It has further been hypothesized that transportation costs between countries will reduce the extent of intra-industry trade. \(^1\) This hypothesis has been tested by introducing geographical distance between the United States and the individual partner countries (D) as a variable in the estimating equation.

Following Falvey (1981), one may further postulate that the extent of intra-industry trade between any pair of countries will vary inversely with trade restrictions between them. In regard to the trade of the United States, this proposition has been reformulated in terms of the level of protection in the partner countries; the higher this level, the less is expected to be the extent of intra-industry trade between the United States and the country in question. In the absence of data on the height of trade barriers in a number of countries, deviations between actual and hypothetical per capita exports have been used as a proxy for trade orientation, with hypothetical values derived from a regression equation incorporating per-capita income, population, the ratio of mineral exports to GNP, and distance from foreign markets as explanatory variables. \(^2\)

### IV

Table 1 shows the results obtained by weighted least squares, using the incorrect as well as the correct adjustment procedures, and by nonlinear least squares, excluding as well as including zero observations. Estimates

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\(^1\) This hypothesis rests on the assumptions made in the model by Krugman (1980) referred to earlier.

\(^2\) For a detailed explanation and the estimating equation actually employed, see Balassa, 1984a.
**Table 1**

The Determinants of Intra-Industry Specialization in U.S. Trade
(Regression coefficients with t-values in parenthesis)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<tbody>
<tr>
<td></td>
<td>Logic Analysis with Weighted Least Squares</td>
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<td>Nonlinear Least Squares Estimates</td>
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<tr>
<td></td>
<td>with incorrect adjustment for heteroscedasticity</td>
<td>with correct adjustment for heteroscedasticity</td>
<td>excluding zero observations</td>
<td>including zero observations</td>
<td>including zero observations but excluding variables with a t-value of less than 1</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.486 (8.61)</td>
<td>-0.183 (1.31)</td>
<td>-0.174 (1.19)</td>
<td>-0.1438 (1.02)</td>
<td>-0.147 (1.09)</td>
</tr>
<tr>
<td>PD</td>
<td>1.385 (6.97)</td>
<td>0.196 (2.44)</td>
<td>0.340 (4.10)</td>
<td>0.473 (6.21)</td>
<td>0.489 (6.69)</td>
</tr>
<tr>
<td>HKT</td>
<td>9.507 (2.74)</td>
<td>1.503 (0.93)</td>
<td>1.785 (1.06)</td>
<td>6.042 (3.85)</td>
<td>5.702 (3.85)</td>
</tr>
<tr>
<td>ADV</td>
<td>11.523 (2.51)</td>
<td>-0.331 (0.21)</td>
<td>0.783 (0.48)</td>
<td>-0.432 (0.28)</td>
<td>-</td>
</tr>
<tr>
<td>SDPR</td>
<td>6.783 (6.44)</td>
<td>0.647 (1.23)</td>
<td>1.445 (2.68)</td>
<td>1.176 (2.38)</td>
<td>1.068 (2.47)</td>
</tr>
<tr>
<td>ECSC</td>
<td>-5.817 (2.95)</td>
<td>-0.675 (0.68)</td>
<td>-2.503 (2.43)</td>
<td>-4.560 (4.46)</td>
<td>-4.679 (4.61)</td>
</tr>
<tr>
<td>LACR</td>
<td>-3.941 (5.09)</td>
<td>-1.020 (2.23)</td>
<td>-1.570 (3.23)</td>
<td>-3.580 (6.11)</td>
<td>-3.633 (6.20)</td>
</tr>
<tr>
<td>FDI</td>
<td>-8.636 (9.07)</td>
<td>-0.293 (0.50)</td>
<td>-0.873 (1.52)</td>
<td>-0.630 (1.20)</td>
<td>-0.824 (1.75)</td>
</tr>
<tr>
<td>AFFL</td>
<td>-0.679 (2.48)</td>
<td>-0.263 (1.74)</td>
<td>-0.289 (1.86)</td>
<td>-0.126 (0.87)</td>
<td>-</td>
</tr>
<tr>
<td>TC</td>
<td>-0.342 (3.15)</td>
<td>-0.037 (0.91)</td>
<td>-0.075 (1.79)</td>
<td>-0.045 (1.16)</td>
<td>-0.051 (1.34)</td>
</tr>
<tr>
<td>OAP</td>
<td>1.501 (5.05)</td>
<td>0.317 (2.44)</td>
<td>0.461 (3.39)</td>
<td>0.591 (4.60)</td>
<td>0.577 (4.55)</td>
</tr>
<tr>
<td>INEQY/P</td>
<td>-3.366 (14.99)</td>
<td>-0.141 (1.13)</td>
<td>-0.735 (5.41)</td>
<td>-1.810 (12.69)</td>
<td>-1.811 (12.69)</td>
</tr>
<tr>
<td>INEQY</td>
<td>-3.678 (9.33)</td>
<td>-0.223 (2.01)</td>
<td>-0.419 (3.58)</td>
<td>-0.905 (8.47)</td>
<td>-0.905 (8.48)</td>
</tr>
<tr>
<td>TC</td>
<td>0.533 (5.59)</td>
<td>0.148 (2.74)</td>
<td>0.213 (3.80)</td>
<td>0.477 (8.76)</td>
<td>0.479 (8.84)</td>
</tr>
<tr>
<td>D</td>
<td>-0.368 (1.71)</td>
<td>-0.485 (4.32)</td>
<td>-0.745 (6.20)</td>
<td>-1.114 (9.35)</td>
<td>-1.116 (9.37)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.8668</td>
<td>0.0997</td>
<td>0.5724</td>
<td>0.4776</td>
<td>0.4775</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>0.328</td>
<td>0.2980</td>
<td>0.2962</td>
<td>0.2634</td>
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obtained using nonlinear least squares are also reported omitting variables that have a t-value of less than 1.

As noted in Section I of the paper, the statistical significance of the regression coefficients declines to a considerable extent if in weighted least squares estimation the incorrect adjustment procedure is replaced by the correct procedure. In turn, the t-values for all the variables rise and the number of statistically significant results increases to a considerable extent if nonlinear rather than weighted least squares (with correct adjustment) estimation is used. This comparison has been made by excluding from estimation by nonlinear least squares the zero observations that are ipso facto excluded under weighted least squares estimation. Finally, in the majority of cases, further improvements occur if zero observations are also included in estimation by nonlinear least squares.

It appears, then, that the theoretically more appropriate nonlinear least squares estimation gives statistically superior results than weighted least squares. At the same time, one needs to include in the estimation the zero observations that indicate the absence of intra-industry trade. Correspondingly, the following discussion is limited to estimates obtained by applying nonlinear least squares estimation to all (zero as well as non-zero) observations with the exclusion of variables that have a t-value lower than 1.

Among the industry variables, the Hufbauer measure of product differentiation (PD) has the expected positive sign and a t-value of 6.7. In turn, with one exception, the product differentiation variables introduced by Caves are not significant at even the 10 percent level. The exception is the marketing variable (MKT) that has a positive coefficient, with a t-value of
5.5. The suggested interpretation of this result is that marketing expenditures increase with the extent of product differentiation.

The standard variation of profit rates variable (SDPR) is also positively related to the extent of intra-industry trade, with a t-value of 2.5. This is the expected result, irrespective of whether one follows Caves in regarding the variability of profit rates as indication of product heterogeneity or the variable is taken to represent product differentiation as suggested above.

The economies of scale variable (ECSC) is negatively correlated with the extent of intra-industry trade, with a t-value of 4.6. This is the expected result as the variable is taken to reflect the extent of product standardization. A negative coefficient, with a t-value of 6.2, is also obtained for the industrial concentration variable (IACR) that is considered to be another indicator of product standardization.

Foreign direct investment (FDI) and trade with foreign affiliates (AFFL) are highly correlated. This explains why neither of the two variables is significant statistically, when they are introduced simultaneously in the estimating equation. The FDI, but not the AFFL, variable is statistically significant at the 10 percent level and has the expected negative sign if introduced separately in the estimating equation.

The transportation cost variable (TC) also has the expected negative sign but its statistical significance falls below the 10 percent level if zero observations are included in the estimation. Finally, the offshore assembly variable (OSA) has the expected positive sign and a t-value of 4.6.

Among country variables, the inequality measures for per capita GNP (INEQY) and for the gross national product (INEQG) variables have the
expected negative signs, with t-values of 12.7 and 8.5, respectively. Thus, the assumed relationship between similarities in income levels and market size on the one hand, and the extent of intra-industry trade, on the other, is confirmed by the empirical results.

Furthermore, as expected, trade orientation is positively correlated with the extent of intra-industry trade while a negative correlation is obtained with respect to distance. Both of these variables are highly significant statistically, with t-values of 8.8 and 9.4, respectively.

The coefficient of determination of the regression equation is 0.48, indicating that nearly one-half of the variation in the index of intra-industry trade is explained by the industry and country variables utilized in the estimation. In turn, the standard error of the regression equation is 0.26.

This paper has set out to explain the extent of intra-industry specialization in United States trade with 37 countries exporting manufactured goods in 167 manufacturing industries. This has been done by testing hypotheses derived from international trade theory in regard to the interindustry and intercountry determinants of the extent of intra-industry trade.

Utilizing data on U.S. trade with 37 trading partners in individual industries, it has been found that the extent of intra-industry trade is positively correlated with product differentiation, marketing costs, the variability of profit rates, and offshore procurement, and it is negatively correlated with economies of scale, industrial concentration, foreign direct investment, and transportation costs. These results confirm the theoretical
expectations and the regression coefficients are statistically significant at least at the 10 percent level, the exception being the transportation cost variable. It may be added that the marketing costs and profit variability variables also represent product differentiation while the economies of scale and industrial concentration reflect the extent of product standardization.

It has further been shown that the extent of intra-industry specialization in U.S. trade with individual countries is positively correlated with the extent of trade orientation in these countries and negatively correlated with inequalities in per capita incomes and total GNP and with distance between the U.S. and the individual countries. Again, the results conform to theoretical expectations and the regression coefficients are statistically significant at least at the 10 percent level.

These results have been obtained by nonlinear least squares estimation that is superior to weighted least squares on theoretical grounds as well as owing to the inclusion of zero observations, indicating the absence of intra-industry trade, that account for nearly one-third of the observations. And while it may be expected that the large number of zero observations reduce the coefficient of determination, the explanatory power of the regressions is rather high.
References


