

## Determinants of Intra-Industry Trade Between Developing Countries and the United States

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This study identifies country and industry-level determinants of intra-industry trade (IIT) between the United States and developing countries. IIT is found to decline with greater differences in relative factor endowments. Economic size and trade orientation of the developing country influence IIT in a positive way. Distance exerts a negative effect on IIT. Results show IIT occurs in nonstandard, made-to-order, vertically differentiated, labor intensive products produced by large globally integrated industries. No support is provided for the role of scale economies in determining North-South IIT. Theoretical and empirical models of North-South trade should focus on sources of IIT related to country characteristics, vertical product differentiation based on quality differences, the degree of product standardization, and labor cost differences between the North and South.

### I. Introduction

Considerable research effort has been devoted to identifying determinants of intra-industry trade - the simultaneous import and export of goods falling under the same industry classification. Studies using a cross-section of industries have emphasized determinants of IIT relating to scale economies, product differentiation, and imperfect competition.<sup>1</sup> A second group of studies has identified country characteristics that influence the extent of IIT.<sup>2</sup> Included here are per capita income, country size, transactions cost, and trade orientation. Other studies have attempted to jointly evaluate these influences using a multi-country multi-commodity framework.<sup>3</sup>

Most empirical and theoretical research has focused on two-way trade between industrial nations. Theoretical models are based on scale economies, imperfect competition, and horizontal product differentiation, where each industry produces a variety of goods with similar factor intensities and distinguishable product attributes.<sup>4</sup> Theoretical models

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1. See Greenaway, Hine, and Milner (1995), Clark (1993), Lundberg (1992), Ray (1991), Hamilton and Kniest (1991), Lundberg (1982), Toh (1982), Caves (1981), and Pagoulatos and Sorensen (1975).

2. See Stone and Lee (1995), Balance, Forstner and Sawyer (1992), Globerman and Dean (1990), and Helpman (1987).

3. See Bergstrand (1990), Balassa and Bauwens (1987), Balassa (1986), and Loertscher and Wolter (1980).

4. See Ethier (1982, 1979), Helpman (1981), Krugman (1983, 1981, 1980, 1979), Lancaster (1980), Dixit and Norman (1980), and Dixit and Stiglitz (1977).

of IIT between industrial nations and developing countries (North-South IIT) are gaining in popularity.<sup>5</sup> These models relate the share of IIT to cross-country differences in relative factor endowments and the economic size of trading nations. IIT is a consequence of vertical product differentiation based on product quality differences, rather than as a result of horizontal product differentiation. Labor cost differentials between the North and South are the driving force behind North-South IIT.

There have been few empirical studies of the determinants of North-South IIT.<sup>6</sup> The scarcity of such studies stems from a recognition that North-South trade flows consist primarily of inter-industry trade which can be adequately explained using the traditional Heckscher-Ohlin model that emphasizes differences in relative factor endowments and technologies as a cause of trade. However, a growing proportion of North-South trade seems to be taking place within industry classifications. According to Ballance, Forstner, and Sawyer (1992), the share of the South's trade with the North in manufactures which consists of IIT rose from 8.9 percent to 14.9 percent between 1970 and 1985.

Table 1 presents indexes of IIT in United States' trade with developing countries. These indexes show the share of total trade that consists of two-way exchanges of products within the same industry classification. Overall, 50 percent of trade in manufactured goods between the U.S. and 155 developing countries and territories consists of IIT. The corresponding figure for trade between the U.S. and the 30 largest developing countries is 48.5 percent. A wide variety of industries are found to exhibit significant amounts of IIT. Two-way trade in similar goods takes place in industries supplying consumer goods, producer goods, components, high and low-technology goods, natural resource intensive products, and labor intensive assembled products.

**Table 1 Grubel-Lloyd Indexes of IIT in United States' Trade (1992)**

SIC	Industry	All Developing Countries	30 Largest Developing Countries
20	Food and kindred products	0.340	0.336
21	Tobacco products	0.009	0.010
22	Textile mill products	0.527	0.413
23	Apparel and other textile products	0.227	0.200
24	Lumber and wood products	0.355	0.307
25	Furniture and fixtures	0.525	0.459
26	Paper and allied products	0.287	0.283
27	Printing and publishing	0.718	0.676
28	Chemicals and allied products	0.376	0.380
29	Petroleum and coal products	0.715	0.851

5. See Flam and Helpman (1987), Falvey and Kierzkowski (1987), Helpman and Krugman (1985), and Falvey (1981).

6. Balassa and Bauwens (1987) and Ray (1991) focus on North-South trade. Ballance, Forstner and Sawyer (1992) identify country-level determinants of IIT between 20 developed and 25 developing countries.

**Table 1 (Continued)**

SIC	Industry	All Developing Countries	30 Largest Developing Countries
30	Rubber and misc. plastics prod.	0.724	0.569
31	Leather and leather products	0.207	0.129
32	Stone, clay and glass products	0.512	0.499
33	Primary metal industries	0.791	0.795
34	Fabricated metal industries	0.630	0.610
35	Industrial machinery and equip.	0.444	0.458
36	Electronic and electrical equip.	0.740	0.724
37	Transportation equipment	0.432	0.446
38	Instruments and related products	0.567	0.574
39	Miscellaneous manufacturing	0.431	0.297
	All industries	0.504	0.485

Note: Figures represent trade-weighted averages of 4-digit SIC level calculations. "All Developing" countries refers to 43 Western Hemisphere and 112 Eastern Hemisphere developing and newly industrializing countries. Results are also shown for the 30 largest countries that account for 96 percent of U.S. exports and 91 percent of U.S. imports. These countries are Argentina, Bahamas, Brazil, Chile, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Guatemala, Honduras, Hong Kong, India, Indonesia, Jamaica, Korea Rep., Malaysia, Mexico, Panama, Pakistan, Peru, Philippines, Russia, Saudi Arabia, Singapore, Taiwan, Thailand, Turkey, and Venezuela.

The present paper investigates country and industry-level determinants of North-South IIT between the United States and the 30 largest developing countries. Several features of the present study represent improvements over earlier attempts to estimate determinants of IIT. First, this study uses more recent data on trade flows. Data pertain to 1992. Previous studies use data from the 1970s and 1980s. Second, limited dependent variable and panel data techniques are used to analyze determinants of IIT. A third improvement pertains to the scope of country and industry coverage. The present study is based upon 30 developing countries and 300 four-digit U.S. SIC industries. Other studies use far fewer observations and a much higher level of industry aggregation. Greater industry disaggregation will provide a more detailed and accurate analysis of IIT. Finally rather than focusing on a narrow range of potential influences, the present study accounts for a wide variety of country characteristics and industry structural determinants suggested by models of North-South trade.

## II. Models of North-South IIT

Helpman and Krugman (1985) explore the role of country characteristics in determining North-South IIT. The most important difference between these regions lies in their relative factor endowments. The North is relatively capital abundant and the South is labor abundant. Each region produces a differentiated, relatively capital-intensive manufactured good under conditions of increasing returns to scale in a monopolistically

competitive market, and a homogeneous labor-intensive good under constant returns to scale. Consumers in both regions demand variety. The South exports the labor intensive good. Both regions produce and export varieties of the differentiated good, but the North is a net exporter of manufactures. Here, IIT in a capital intensive differentiated good produced under increasing returns to scale coexists with inter-industry trade in a labor intensive good caused by inter-country differences in relative factor endowments.

Helpman and Krugman (1985) demonstrate the volume of IIT depends on both relative factor endowments and economic size of trading nations. A proportional reallocation of productive factors that makes the North and South more (less) unequal in economic size is shown to reduce (increase) the volume of IIT. When a reallocation of factors does not alter the relative size of the North and South, but increases (decreases) the disparity in relative factor endowments, the volume of IIT will decrease (increase). Thus, IIT will tend to decrease (increase) with greater (smaller) differences in relative factor endowments and economic size between the North and South.

Flam and Helpman (1987), Falvey and Kierzkowski (1987), and Falvey (1981) examine industry-level determinants of North-South trade. IIT is viewed as a consequence of vertical product differentiation based on quality differences, rather than as a result of scale economies or horizontal product differentiation. Each industry is defined to include a variety of products differing in quality. Technology reflected in labor productivity differences and/or factor endowments determines the range of qualities produced. The autarky equilibrium is one in which the North enjoys a comparative advantage in capital intensive high quality products and the South specializes in the production of labor intensive lower quality products. Intra-industry trade arises because consumers desire different product qualities in accordance with their income levels, and because the range of qualities produced in each country differs from the range of qualities desired. The resulting trade pattern is one in which the North exports high quality products to the South in exchange for lower quality products falling under the same industry classification.

### **III. Determinants of North-South IIT**

Variables suggested by models of North-South trade are used to identify country and industry-level determinants of IIT in bilateral trade between the U.S. and 30 developing countries. Helpman and Krugman (1985) relate the share of IIT to cross-country differences in relative factor endowments and relative country size. The more countries differ in relative factor endowments, the smaller the share of IIT. As the size of the trading partner grows, the U.S. and a developing country become more similar in size. The size of the smaller country will have a positive effect on the share of IIT. We expect IIT will be negatively related to differences in factor endowments (DIFF), proxied by differences in per capita GDP, and positively related to the size (GDP) of the developing country.<sup>7</sup>

7. This specification is used in Helpman (1987). Helpman and Krugman (1985) interpret differences in per capita income as differences in the capital-labor endowment ratio. A preferred approach would be to use

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the actual capital-labor endowment ratio. These figures are unavailable for most developing countries and are likely to be unreliable when available. Linder (1961) and other studies use per capita income differences as proxies for consumer tastes.

Distance between trading partners serves as a proxy for costs of information necessary for trading nonstandardized products. Balassa and Bauwens (1987) argue more information is required on characteristics of nonstandardized products than on characteristics of standardized goods. Frictions associated with overcoming distance will deter trade proportionately more for closely substitutable nonstandardized products than for standardized goods.<sup>8</sup> IIT should be negatively correlated with distance (DIST) between the U.S. and a trading partner.

Trade orientation of a developing country will also influence IIT. Falvey's (1981) model shows countries with lower trade barriers will have higher levels of IIT. Following Stone and Lee (1995), Balassa and Bauwens (1987), and Balassa (1986), trade orientation is proxied by the residuals from a regression of per capita trade (exports plus imports) on per capita income and population. The share of IIT will be positively correlated with the developing country's trade orientation (TO).

Grubel and Lloyd (1975) note their measure of IIT will be affected by the trade imbalance of a country. This effect will be greater the larger the share of net trade and the smaller the share of IIT in total trade. The index should be negatively correlated with the trade imbalance so estimated coefficients in the regression equation will be biased if the trade imbalance is correlated with the explanatory variables. Following Stone and Lee (1995), we include a measure of the trade imbalance to control for this possible bias. IIT is expected to be negatively correlated with the trade imbalance (TIMB).<sup>9</sup>

A variety of industry-level characteristics are also expected to influence North-South IIT. The scope for IIT will be influenced by the degree of product standardization and differentiation, as well as by the globally integrated nature of the production process.

According to Balassa (1986) and Greenaway and Milner (1986), plant-level scale economies are captured in industries producing standardized products whose costs decline with increases in plant size. This horizontal specialization results in standardized products that are associated with inter-industry trade. Vertical specialization entails producing parts, components, accessories, and the final product in different plants. Plant size is decreased rather than increased as operations are subdivided among a number of plants. Vertical specialization leads to non-standardized products and IIT. Traditional measures of plant level scale economies, such as the minimum efficient scale (MES), are positively correlated with the degree of product standardization. MES is the average sales per firm for firms in the midpoint class size (defined by product shipments), as a percent of 1992 shipment values.<sup>10</sup> Since MES reflects the degree of product standardization, and non-standardized products are associated with IIT, the share of IIT in North-South trade is expected to be negatively correlated with MES.

Three factors serve as additional proxies for potential gains from intraindustry

8. Distance can also reflect such factors as seasonal trade, border trade, regional economic integration, cultural and language differences, and general market familiarity.

9. Following Stone and Lee (1995),  $TIMB_j = |X_j - M_j| / (X_j + M_j)$ , where  $X_j$  and  $M_j$  are exports and imports of developing country  $j$  in world trade.

10. MES is considered to be the preferred measure of internal scale economies. See Caves, Khalilzadeh-Shirazi, and Porter (1975).

specialization. Product standardization is also related to the extent of seller concentration and the number of establishments in an industry. Balassa (1986) argues the number of differentiated products produced in an industry will decline as seller concentration increases. Industries with many establishments will produce a larger number of differentiated products. The four-firm seller concentration ratio expresses the percent of 1992 shipment values accounted for by the four largest firms. The share of IIT is expected to be negatively correlated with the four-firm seller concentration ratio (CR4), and positively correlated with the number of establishments (ESTAB).

The sectoral dispersion index, which reflects the diversity of industry consumers, serves as a proxy for potential gains from intraindustry specialization. Lower values of this index are associated with industries serving a wide variety of industrial consumers who are likely to do so with made-to-order products. IIT is expected to be negatively correlated with the sectoral dispersion index (DSPH).<sup>11</sup>

North-South trade models view IIT as a consequence of vertical product differentiation based on quality differences. The North exports high quality products to the South in exchange for lower quality products falling under the same industry classification. Vertical product differentiation is proxied by the 1987 advertising-to-sales ratio. Advertising is intended to differentiate products, exploit quality differences, shift the demand function, and/or change the price elasticity of demand for a product. The scope for vertical product differentiation based on product quality differences will be greater in industries with high advertising intensity. North-South IIT is expected to be positively correlated with the advertising-to-sales ratio (AS).

Two variables influencing North-South IIT relate to the nature of the production process. The first of these is the capital intensity of production, measured by the capital-to-labor ratio. North-South IIT involves the North exporting capital intensive high-quality products and components to the South in exchange for labor intensive lower-quality products and components falling under the same industry classification. Factor intensity will influence the range of qualities produced. The scope for producing a product in low-labor-cost countries is greater the more labor intensive is the industry. IIT is expected to be negatively related to the capital-to-labor (KL) ratio.

The globally integrated nature of an industry is proxied by industrial participation under offshore assembly provisions (OAPs) in the U.S. tariff code.<sup>12</sup> OAPs refer to items HTS 9802 of the Tariff Schedule of the United States. HTS tariff item 9802.00.60 (formerly 806.3) allows metal articles to be imported duty-free into the U.S. except for the value of processing performed abroad. HTS item 9802.00.80 (formerly 807.00) covers imported articles assembled abroad with U.S. - made components. Duties are assessed on the full value of the item less the value of the U.S. - made components embodied in them. Imports under this provision account for 99 percent of the total value of OAP imports.

11.  $DSPH_i = \sum_{j=1}^I s_{i,j}^2$ , where  $s_{i,j}$  is the share of industry  $i$ 's sales to two-digit consuming industry  $j$ . See Lustgarten (1975).

12. See U.S. International Trade Commission (1996, 1988).

Balassa (1986) argues OAPs encourage vertical product specialization. Industries with vertically integrated production processes can use OAPs to rationalize production in accordance with the pattern of comparative advantage. A U.S industry will export high and intermediate-technology products and components, and import low-technology labor intensive products and components. OAP is measured as the share of OAP imports in total 1992 imports. The share of IIT is expected to be positively correlated with OAP activity.

A final variable is included to proxy categorical aggregation. Several studies have argued that IIT should fall when finer levels of product aggregation are used to define industries. This leads to an expectation that large industries comprised of many product groups should have more IIT than industries with only a few product groups. Following Marvel and Ray (1987), categorical aggregation is proxied by the value of industry shipments, assuming more aggregation is involved in industries with higher shipment values. IIT is expected to be positively correlated with the value of industry shipments (VS).

Country characteristics are taken from United Nations (1997), the Economist (1997), and Fitzpatric and Modlin (1986). DIFF is measured in U.S. dollars. GDP is expressed in millions of U.S. dollars. Distance is in kilometers. Export and import figures used to construct the IIT index are from the U.S. Bureau of the Census (1993). The value of OAP imports is from the U.S. Bureau of the Census (1995a). CR4 is from the U.S. Bureau of the Census (1992). DSPH and AS are calculated from the U.S. Department of Commerce (1994). MES, ESTAB, KL, and VS are from the U.S. Bureau of the Census (1995b). KL is measured in millions of U.S. dollars of capital per worker in an industry. ESTAB is measured in tens of thousands. VS is expressed in millions of U.S. dollars.

#### IV. Estimation Methods

The present paper uses the Grubel-Lloyd (1975) measure of intra-industry trade, expressed as

$$IIT_i = [1 - |X_i - M_i| / (X_i + M_i)], \quad (1)$$

where  $X_i$  is exports of industry  $i$ ,  $M_i$  is imports of industry  $i$ ,  $|X_i - M_i|$  is net trade,  $(X_i + M_i)$  is total trade,  $i = 1, 2, \dots, n$  and  $0 \leq IIT_i \leq 1$ . An index value of 0 would indicate complete inter-industry trade. Here, either the value of exports or imports would be zero. Higher index values are associated with greater intra-industry trade as a proportion of total trade, with an index value of 1 indicating equality between exports and imports.

Limited dependent variable and panel data techniques are used to analyze determinants of IIT. Previous studies have used OLS regression specifications, with a mix of linear-log and logistical functional forms. Values of zero IIT are important. Nearly half of the observations in our data set show complete inter-industry specialization. The distribution of the IIT variable is observed for only a limited range and is censored

at zero. Coefficients from the conventional OLS regression on IIT would be biased and inconsistent since they do not account for the difference between limit (zero) observations and nonlimit (continuous) observations.

Probit and tobit models are used to correct for binary choice and censoring.<sup>13</sup> The probit model analyzes the process underlying the achievement of positive IIT. Observations consists of whether IIT exists ( $y=1$ ) or not ( $y=0$ ). The adjusted regression coefficients help explain factors underlying the hurdle to starting IIT. In the tobit model, both the initial hurdle to positive IIT and continuous increases in trade are captured in the index function  $y^*$ , with the variable " $y$ " being the observed value. In other words, the probability of a positive outcome is determined along with the level of positive trade. This model is appropriate since we have data on both zero and positive IIT. The basic tobit structure is

$$y_{ij}^* = \beta' x_{ij} + \varepsilon_{ij}, \tag{2}$$

where  $\varepsilon_{ij} \sim N[0, \sigma^2]$  across  $i$  countries and  $j$  industries. If  $y_{ij}^* \leq 0$ , then  $y_{ij} = 0$ . If  $y_{ij}^* > 0$ , then  $y_{ij} = y_{ij}^*$ , implying  $y_{ij} = \max[0, y_{ij}^*]$ . In the standard tobit regression, there is censoring of the normal distribution at 0 for the lower tail. Adjustment is made for this censoring so the corrected predicted values account for the lower limit and fall within the plausible range of [0,1] consistent with IIT. The maximum likelihood estimator of the tobit model will still be inconsistent if heteroskedasticity occurs, so additional estimates are often needed.

We also give specific attention to the country effects that correlate with IIT by undertaking a second set of regressions using panel data methods. Many studies have focused on industry effects, or industry and country effects, without accounting for unobservable national factors that may vary systematically across observations. The importance of factor endowment differences, national income, trade orientation and other factors can be explicitly controlled for in a regression. Additional "intangibles" (such as national industrial policy, managerial know-how, etc.) may correlate with a country's observed incidence of high IIT across products and cause a more complicated heteroskedasticity problem.<sup>14</sup>

Panel data techniques incorporate these country effects. The essential structure for these techniques is a linear OLS model with group effects. Here, there are multiple industry observations within each country group,

$$y_{ij}^* = \mu_j + \beta' x_{ij} + \varepsilon_{ij}, \tag{3}$$

$\varepsilon_{ij} \sim N[0, \sigma^2]$  across  $i$  countries and  $j$  industries, with  $\mu$  as the constant country-

13. See Maddala (1983) and Greene (1997).  
 14. Likewise, there may be intangible industry effects that correlate with a high level of IIT. A greater degree of disaggregation of the industries (which we do) controls for part of these effects. Panel data methods were also used to focus on industries as the key "group" effect, but results were less significant than country effects.

specific effect.

Given the presence of a large number of “industry-invariant” variables in fixed national data, a random effects specification is most convenient and logical for a sample. The differences across country groups are placed in the error term. The country-specific effect is treated as an individual disturbance under a generalized regression model,

$$y_{jt}^* = \alpha + \beta' x_{jt} + \varepsilon_{jt} + \nu_j, \text{Cov}[\varepsilon_{jt} + \nu_j] = \sigma_\varepsilon^2 + \sigma_\nu^2. \quad (4)$$

Here the component  $\nu_j$  is the random disturbance for the  $j$ th country group and is constant across all different industry transactions. A generalized least squares estimator is used to estimate the random effects model by weighting the within and across (country) group variations  $\sigma_\varepsilon^2$  and  $\sigma_\nu^2$ , and estimators.

Additionally, the national group effects can be built into corrections for heteroskedasticity and contemporaneous correlation across groups in these linear regression models. The groupwise heteroskedasticity model is appropriate here since there are a large number of industry observations for a relatively small number of countries. This model provides a powerful consistent test of a more general form of heteroskedasticity.<sup>15</sup> Again  $n$  observations are grouped into “ $i$ ” groups, each with some  $n_i$  observations. The slope vector is the same in all groups, but there is a specific variance for each group “ $i$ ”. This groupwise disturbance structures model is described by

$$y_{jt}^* = \alpha + \beta' x_{jt} + \varepsilon_{jt}, \quad (5)$$

with  $\text{Cov}[\varepsilon_{jt-1}, \varepsilon_{jt-2}] = \sigma_{ij} \times I(t=s)$ , groupwise heteroskedasticity as  $E[\varepsilon_{jt}^2] = \sigma_{ij}$ , and cross-group correlation as  $\text{Cov}[\varepsilon_{jt-1}, \varepsilon_{jt-2}] = \sigma_{ij}$ . This model, estimated by Generalized Least Squares, also allows for cross-group (i.e., international) correlation in the national error terms.

## V. Results

Results are presented in Table 2. Probit estimates identify factors that are associated with two-way trade. Results show factor endowment differences and distance both exert negative effects on IIT. Size of the trading partner exerts a positive effect on IIT. The number of establishments, advertising intensity, OAP use, and industry size are positively correlated with IIT. Seller concentration and the sectoral dispersion of industry sales are negatively correlated with IIT. These findings are consistent with the view that IIT consists of trade in nonstandardized products. Capital intensity of an industry is negatively correlated with IIT. The Likelihood Ratio test suggests the probit results predict two-way trade well, and the predicted outcome has the maximum probability in the model.<sup>16</sup>

**Table 2 Determinants of North-South IIT**

15. See Greene (1997).

16. The Likelihood Ratio test statistic of 1875.67 is much larger than the critical value of the  $\chi^2$  distribution for 13 degrees of freedom at the 95% significance level.

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Variable	Panel Data Specification			
	Probit Model	Tobit Model <sup>a</sup>	Random Effects	Groupwise Heteroskedasticity
Intercept	2.677 (4.763)	0.241 (1.636)	0.466 (1.220)	0.230 (2.771)
ln DIFF	-0.494 (-9.354)	-0.091 (-6.968)	-0.052 (-1.445)	-0.032 (-3.925)
ln GDP	0.248 (21.429)	0.075 (19.541)	0.032 (3.764)	0.033 (16.517)
ln DIST	-0.046 (-3.275)	-0.014 (-5.261)	-0.014 (-1.730)	-0.013 (-5.869)
TO	0.021 (0.715)	0.018 (2.333)	0.018 (0.804)	0.018 (3.698)
TIMB	-1.103 (-12.250)	-0.223 (-8.393)	-0.085 (-1.181)	-0.104 (-6.913)
MES	0.057 (0.292)	0.024 (0.474)	0.021 (0.680)	0.028 (0.874)
CR4	-0.004 (-4.644)	-0.001 (-4.251)	-0.001 (-3.270)	-0.001 (-3.830)
ESTAB	0.030 (3.175)	0.002 (1.231)	0.001 (1.083)	0.001 (1.165)
DSPH	-0.141 (-2.453)	-0.100 (-6.325)	-0.064 (-6.233)	-0.030 (-3.225)
AS	3.203 (3.903)	0.774 (3.487)	0.498 (3.464)	0.396 (3.015)
KL	-0.066 (-3.925)	-0.018 (-3.758)	-0.008 (-2.661)	0.003 (0.105)
OAP	5.328 (8.606)	0.598 (18.660)	0.413 (20.564)	0.488 (24.056)
ln VS	0.079 (5.741)	0.015 (4.070)	0.006 (2.341)	0.002 (1.120)
LGDP het.		-0.692 (-10.352)		
F test (13, 8986)	149.76	99.52		
$\chi^2$ /Likelihood	1875.67	-4179.47		
LM Test/LR Statistic			4692.28	993.45

Note: Coefficients, followed by t-statistics in parentheses. N= 9000 (30 countries, 300 industries). The dependent variable in the probit model=1 if IIT was positive, and 0 otherwise. Other specifications use GL as the dependent variable.

<sup>a</sup> Based on heteroskedasticity-corrected standard errors, with ln GDP being the source of variance. A likelihood ratio test of the restricted heteroskedastic model against the unrestricted homoskedastic model rejected the null hypothesis of zero heteroskedasticity (LR=106.8,  $\chi^2_{0.05}(14)=23.69$ ).

The heteroskedasticity-corrected tobit estimates are largely consistent with results of the probit model.<sup>17</sup> The more similar countries are in relative factor endowments,

17. Other forms of heteroskedasticity, particularly by industry characteristics such as value of shipments,

the greater the IIT. Size of the trading partner and trade orientation exert positive effects on IIT, while distance exerts a negative effect. Advertising intensity, OAP use, and industry size positively influence IIT. Seller concentration, sectoral dispersion of industry sales, and capital intensity exert negative effects on IIT.

Country effects are found to have significant explanatory power. Unobservable country effects may change the standard errors of the estimates in a nonlinear fashion. Estimates, incorporating country group-specific disturbances, are reported in the remaining columns of Table 2. Panel data techniques show that even after controlling for random group effects, size of the trading partner exerts a positive effect, and distance a negative effect, on IIT. The large Bueusch-Pagan Lagrange Multiplier (LM) statistic indicates the random effects specification is preferred to OLS.<sup>18</sup> Group effects are incorporated in the (larger) standard errors on the country variables. Effects of observable country variables are offset somewhat by unobservable factors. Although the coefficients are less significant, coefficient signs generally conform to prior expectations. A variety of industry characteristics also affect IIT. Seller concentration, the sectoral dispersion of industry sales, and capital intensity exert negative effects on IIT. Advertising intensity, OAP use, and industry size exert positive influences on IIT.

Finally, groupwise heteroskedasticity results incorporate country effects in a similar fashion.<sup>19</sup> Results suggest both country groupwise heteroskedasticity and cross-country correlation. The corrected covariance matrix is incorporated in the resulting standard errors, with only slight variations in the coefficients. Size of the trading partner and trade orientation exert positive effects on IIT. Factor endowment differences and distance exert negative effects on IIT. As before, seller concentration and the sectoral dispersion of industry sales exert negative effects, and advertising intensity and OAP use exert positive effects, on IIT.

Results are extremely robust across the limited dependent variable and panel data specifications. Relative factor endowment differences and distance exert negative effects, and the size of the trading partner and trade orientation exert positive effects, on IIT. These findings are consistent with those of Balassa and Bauwens (1987), Stone and Lee (1995), and also studies of North-North IIT, such as Helpman (1987).

Seller concentration, sectoral dispersion of industry sales, and capital intensity exert negative effects on IIT. Advertising intensity, OAP use, and industry size affect IIT in a positive way. Results pertaining to seller concentration, sectoral dispersion of sales, capital intensity, and industry size are consistent with findings of Ray (1991). Balassa and Bauwens (1987) also found a negative coefficient on seller concentration and a positive coefficient on OAP use. Collectively, these results show IIT occurs in non-standardized, made-to-order, vertically differentiated products produced by large, globally

were much less significant than the country size effect.

18. The test statistic of 4692.28 is much greater than the 5% critical value from the  $\chi^2$  distribution with 13 degrees of freedom at 22.36.

19. All three tests of heteroskedasticity gave the same results. The Wald statistic of 12279.80, Lagrange Multiplier statistic of 912.26, and Likelihood Ratio test statistic of 993.45 all rejected homoskedasticity under a  $\chi^2$  (13) distribution of 95% significance.

integrated industries.

Findings of the present study do not support the role of scale economies in determining North-South IIT. None of the coefficients on the minimum efficient scale variable are statistically significant. The same result was obtained in Balassa and Bauwens (1987) study of North-South IIT. Ray (1991) established a significant positive relationship between midpoint plant shipments and North-South IIT.

## VI. Conclusions

This study employs variables suggested by models of North-South trade to identify country and industry-level determinants of the extent of IIT between the U.S. and developing countries. IIT is found to fall with greater differences in relative factor endowments (proxied by differences in per capita GDP) between the North and South. Size of the trading partner influences IIT in a positive way. These findings are consistent with predictions of Helpman and Krugman's (1985) theoretical model. Distance influences IIT in a negative way. Trade orientation of the developing country exerts a positive effect on IIT.

Theoretical models of NS trade view IIT as a consequence of vertical product differentiation based on quality differences rather than as a result of scale economies or horizontal product differentiation. Several findings support conclusions of these models. Our finding of a positive relationship between IIT and advertising intensity supports the role of vertical product differentiation. Scale economies are not found to play a role in determining the extent of IIT. This could be due to the fact that low-technology products assembled in developing countries are not easily produced using automated processes in large scale production facilities. Factor intensity of an industry will influence the range of qualities produced. The scope for vertical product differentiation will be greater when goods can be produced with labor intensive production techniques. We find a negative relationship between North-South IIT and the industry capital-to-labor ratio. The North will export high quality capital intensive products to the South in exchange for lower quality labor intensive products falling under the same industry classification. Offshore assembly provision use, our proxy for the globally integrated nature of an industry, exerts a positive influence on the extent of IIT. This finding also supports the role of vertical product differentiation in determining North-South IIT. U.S. industries engaged in production sharing operations tend to export high and intermediate technology products and components and import labor intensive lower-technology products and components.<sup>20</sup>

A considerable share of trade in manufactured goods between the U.S. and developing

20. For example, the types of motors and generators that enter from Mexican plants under OAPs are smaller, less specialized, and lower in price than those produced for export in U.S. facilities. U.S. firms export high and intermediate technology valves and components, and import low-technology valves and components from Mexico. U.S. producers export high-value components such as hydraulic actuators, and high-pressure valve stems, seals, and seats, and import simple steel and iron valve body housings from Mexico. For additional examples, see U.S. International Trade Commission (1996, Chapter 4).

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countries is found to consist of IIT. As trade liberalization continues the share of IIT in total trade can be expected to grow. IIT will be greater as countries become more similar both in relative factor endowments and economic size. More IIT will occur in vertically differentiated, nonstandard, made-to-order products produced by large, globally integrated industries. Theoretical and empirical models of North-South trade should focus attention on sources of IIT related to country characteristics, vertical product differentiation based on quality differences, the degree of product standardization, and labor cost differences between the North and South.

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