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INTRA-INDUSTRY SPECIALIZATION:
A MULTI-COUNTRY PERSPECTIVE

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(with a Technical Appendix by Luc Bauwens)

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Abstract

This paper has tested various hypotheses as to the determinants of intra-industry trade in thirty-eight developed and developing countries exporting manufactured goods. The econometric estimates for the entire group of countries show that the extent of intra-industry trade increases with the level of economic development (GNP per head), the size of domestic markets (GNP), and the openness of national economies. The existence of trading partners with common borders and geographical proximity further contributes to intra-industry trade.

These hypotheses have also been confirmed for the developing country group. And while similarities in regard to trade orientation and the existence of border trade, as well as intercorrelation between the gross national product and per capita GNP, have reduced the statistical significance of the regression coefficients for these variables for the developed country group, the equation has a high explanatory power.

INTRA-INDUSTRY SPECIALIZATION: A MULTI-COUNTRY PERSPECTIVE

Bela Balassa

Since the time this author first introduced the concept of intra-industry -- as compared to inter-industry -- trade (Balassa, 1966), a vast literature has developed on the subject. Efforts at the measurement of the extent of intra-industry specialization, i.e. its relative importance within a country's total trade, have been complemented by research on the theory of intra-industry trade and its determinants. 1/

The present paper investigates the determinants of intra-industry specialization in a cross-country framework, by taking the country as the unit of observation. It sets out to explain the extent of intra-industry trade in countries exporting manufactured goods by reference to country characteristics affecting such trade. This is a neglected area as most contributions have examined the effects of commodity characteristics on intra-industry specialization. Exceptions are Loertscher and Wolter (1980) and Havrylyshyn and Civan (1983), to which reference will be made below.

Section I of the paper will consider a variety of possible hypotheses that may be put forward to explain the extent of intra-industry trade in a cross-country framework. Section II will describe the methods and data used in the process of estimation. Section III and IV, respectively, will provide the empirical results for all the countries under study and for the developed and developing country subgroups, respectively. Section V will provide a brief overview of the principal findings.

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

I

Staffan Burenstam Linder (1961) was the first to suggest that, at higher levels of economic development, international trade will increasingly involve the exchange of differentiated products; i.e. intra-industry specialisation. Following Linder, one may formulate the hypothesis that the extent of intra-industry trade will be positively correlated with the level of economic development.

In turn, starting with Krugman (1979) and Lancaster (1980), a number of writers have emphasized the role of economies of scale in intra-industry trade. They have shown that, in the event of product differentiation, economies of scale will give rise to intra-industry specialization between countries with identical resource endowments, production functions, and tastes. Subsequently, Krugman (1980) has concluded that, in the event of transportation costs, a country with a larger domestic market will be a net exporter of differentiated products subject to economies of scale and a country with a smaller domestic market will be a net exporter of standardized products subject to constant returns to scale. Special cases aside, there will nevertheless be intra-industry trade in the products subject to economies of scale, with larger countries accounting for a relatively high proportion of this trade. Correspondingly, it may be hypothesized that the extent of intra-industry trade will be positively correlated with the size of domestic markets.

Krugman (1980) has further shown that, in a model of product differentiation under economies of scale, with trade taking place between two identical countries, the introduction of transportation costs in the form of a uniform loss in transit per unit of product will not affect the number of firms or output per firm in either country. However, the prices of imported goods will rise relative to the prices of domestic goods in both countries, thereby leading to a decline in the volume of intra-industry trade. Thus, one may hypothesize that the extent of such trade will be negatively correlated with transportation costs.

In a model of intra-industry trade incorporating specific capital and constant returns to scale, Falvey (1981) has concluded that the volume of this trade will vary inversely with the level of trade restrictions. In analogy to transportation costs, this conclusion can be extended to the case of intra-industry trade in products subject to economies of scale. One may then put forward the hypothesis that the extent of intra-industry trade will be negatively correlated with the level of trade restrictions.

Grubel and Lloyd have suggested that, in countries sharing a common border, intra-industry trade may occur "in products which are functionally homogeneous but differentiated by location" (1975, p. 75). Correspondingly, it can be hypothesized that the extent of intra-industry trade will increase in a country that shares a common border with its trading partners.

Finally, this author has examined the relative importance of intra-industry trade in the framework of integation arrangements in Western Europe (1966 and 1975) and in Latin America (1979). In the following, it will be hypothesized that economic integration tends to increase the extent of intra-industry trade.

II

In the present paper, the hypotheses put forward to explain the extent of intra-industry trade in particular countries have been tested in a cross-country framework. This has involved explaining intercountry differences in the extent of intra-industry trade by simultaneously introducing the described hypotheses in the estimating equations.

The investigation has been limited to manufactured goods that are characterized by product differentiation and are subject to economies of scale, with the exclusion of natural resource products whose trade is much influenced by the availability of such resources in individual countries. The commodity classification scheme utilized has been established on the basis of the United States Standard Industrial Classification, 1/ with 4-digit SIC categories merged in cases when the economic characteristics of the products in question were judged to be very similar. 2/

The investigation covers 38 countries whose manufactured exports exceeded $300 million in the year 1979 and accounted for at least 18 percent of their total exports. This benchmark has been chosen in order to avoid spurious correlations between the extent of intra-industry trade and the level

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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, sawmill 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. In turn, all SITC categories in classes 5 to 8 were included in the Loertscher-Wolter study and these classes less iron and steel (68) in the Havrylyshyn-Civan study.

2/ This contrasts with investigations by other authors, including the studies by Loertscher-Wolter and Havrylyshyn-Civan, which used the 3-digit Standard International Trade Classification for this purpose. The 3-digit SITC scheme is to a considerable extent arbitrary and cannot be regarded as an economically meaningful classification. -- In earlier work by the author, a combination of 3-and 4-digit SITC items has been used to establish an economically meaningful classification scheme (1966). The use of an industry classification scheme utilized in the present paper is, however, superior to this trade classification scheme.

of economic development through the inclusion of countries which hardly export any manufactured goods. 1/

The investigation pertains to the year 1971. The index of intra-industry trade for a particular country (IIT_j) has been derived as in (1), where X^e_{ji} and M^e_{ji}, respectively, refer to the adjusted exports and imports of commodity i by country j. The formula makes adjustment for the imbalance in total trade, when X_j stands for total exports and M_j for total imports. 2/ The index takes values from 0 and 1 as the extent of intra-industry trade increases. 3/

$$(1)\quad IIT_j = 1 - \frac{\sum_i |X^e_{ji} - M^e_{ji}|}{\sum_i (X^e_{ji} + M^e_{ji})} = 1 - \frac{\sum_i \left| \frac{X_{ji}}{X_j} - \frac{M_{ji}}{M_j} \right|}{\sum_i \left(\frac{X_{ji}}{X_j} + \frac{M_{ji}}{M_j} \right)}$$

$$\text{where } X^e_{ji} = X_{ji}\frac{X_j + M_j}{2X_j} \text{ and } M^e_{ji} = M_{ji}\frac{X_j + M_j}{2M_j}$$

1/ Loertscher-Wolter limited their investigation to the OECD countries while Havrylyshyn-Civan included a number of low income countries that export little manufactured goods. In the 62 country sample used by these authors, the share of manufactured products in total exports did not reach 1 percent in Nigeria, the Central African Republic, Sudan, and Algeria while manufactured goods account for over 70 percent of total exports in most of the developed countries.

2/ A consistent adjustment procedure was first proposed by Aquino (1978). However, while Aquino adjusted for the imbalance in trade in manufactured goods, in the present investigation adjustment has been made for the imbalance in total trade, so as to allow for inter-industry specialization between primary and manufactured goods (Balassa, 1979). -- The Aquino adjustment is used in the Loertscher-Wolter and Havrylyshyn-Civan studies.

3/ I am indebted to Carl Christ for suggesting the transformation of equation (1) shown here.

The level of development has been defined as GNP per head (Y/P). A dummy variable for developed and for developing countries has also been tried, but it has given poor statistical results. At any rate, the use of a continuous variable that recognizes the existence of gradation over the scale of economic development is preferable to a dummy variable that provides a binary classification.

Market size has been represented by the gross national product (Y). While the domestic consumption of manufactured goods would have been a more appropriate measure of the size of domestic market for these products, the necessary data are not available for several countries and are subject to considerable error for others. At the same time, from available information it appears that the consumption of manufactured goods and the gross national product are highly correlated.

Transportation costs have been introduced in the form of a variable for propinquity. This has been defined as the weighted average of the inverse of distance (D) between country j and partner country k, the weights being the gross national product (Y) of the partner countries $\sum_k (Y_k/D_{jk}) \;/\; \sum_k Y_k$.

In recent years, developed countries have made increased use of import restrictions that are the principal measures of protection in most developing countries. Estimates of the tariff equivalent of these measures are few and far between and, at any rate, their use is appropriate only under competitive conditions. This being the case, an indicator of trade orientation has been used to represent the level of trade restrictions.

Trade orientation has been defined in terms of deviations of actual from hypothetical values of per capita exports. Hypothetical values have been derived from a regression equation that, in addition to the per capita income and population variables utilized in early work by Chenery (1960), includes variables representing the availability of mineral resources and distance from foreign markets. The latter two variables have been included on the expectation that, ceteris paribus, the availability of mineral resources and propinquity will raise per capita exports. 1/

Mineral resource availability has been represented by the ratio of mineral exports (X^m) to the gross national product while propinquity has been defined as stated above. The results are reported in equation (2), with t-values shown in parenthesis. As is apparent, the equation has a high explanatory power and all the regression coefficients are significant at the 1 percent level, using a one-tail test.

$$(2) \quad \log \frac{X_j}{P_j} = \underset{(-0.38)}{-0.1864} + \underset{(15.02)}{0.9212} \log (Y_j/P_j) - \underset{(-6.38)}{0.3541} \log P_j$$

$$+ \underset{(2.91)}{0.02510}\, X_j^m/Y_j + \underset{(2.06)}{0.0598} \sum_k \frac{Y_k/D_{jk}}{\Sigma Y_k} \; ; \; \bar{R}^2 = 0.9404$$

In turn, the border trade variable has been given a value of 1 for countries that have a common border with at least one of the trading partners under consideration. Dummy variables have also been introduced for membership

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1/ The described procedure has first been utilized in Balassa, 1983; a distance variable has been added in the present paper. While population appears in the terms shown on the two sides of the equation, as in Chenery's original formulation, this should not affect the appropriateness of using deviations from hypothetical values as an indicator of trade orientation.

in the European Common Market and the Latin American Free Trade Area, as well as for Singapore that has considerable entrepot trade.

III

Three alternative estimation procedures have been used: ordinary least-squares, nonlinear least-squares utilizing a logistic function, and the logit analysis of the same logistic function with weighted least-squares. 1/

The three alternative estimation procedures have given similar results in terms of the statistical significance of the variables and the explanatory power of the regression equations, indicating the robustness of the estimates. 2/ The best statistical results are reported in Table 1.

The regression coefficients of income per head, the gross national product, the trade orientation variable, the proximity variable, and the Singapore dummy are all statistically significant at the 1 percent level in every equation while the border dummy is significant at least at the 5 percent level. However, the dummy variables for economic integration are not significant at even the 10 percent level in any of the equations, when combined with the above variables, and they have been dropped from the estimating equations.

1/ As noted in the Technical Appendix, the use of the latter estimation procedure has involved redefining the dependent variable of the regression equation. The logistic function is more appropriate in the present case as the dependent variable takes values between 0 and 1; use has also been made of ordinary least-squares, however, in part to test the sensitivity of the results to the choice of the estimation procedure and in part for comparability with other studies.

2/ This has also been the case in using the logit procedure with ordinary least-squares, the results of which are not reported here in order to economize with space.

Table 1

Estimates of Intra-Industry Trade
for Countries Exporting Manufactured Products
(regression coefficients with t-values in parenthesis)

	Ordinary Least Squares	Nonlinear Least Squares	Logit Analysis with Weighted Least Squares
Constant	0.176 (5.26)	-1.604 (8.45)	-1.530 (8.10)
Proximity	0.141 (5.72)	0.611 (4.60)	0.550 (4.02)
Border Dummy	0.098 (2.90)	0.469 (2.07)	0.532 (2.42)
Per Capita GNP	0.061 (4.10)	0.377 (4.34)	0.347 (4.20)
GNP	0.054 (4.84)	0.204 (3.80)	0.219 (3.81)
Trade Orientation	0.128 (4.52)	0.612 (4.28)	0.600 (3.85)
Singapore Dummy	0.333 (3.95)	1.413 (3.94)	1.371 (3.36)
$\bar{R}^2$	0.8977	0.9784	0.8394
$\hat{\sigma}$	0.0670	0.0659	0.0673
N	38	38	38

Note: For definition of variables and explanation of methodology, see text and Technical Appendix. The proximity, per capita GNP, and GNP variables have been scaled in terms of 10,000 miles, 1,000 dollars, and 100,000 dollars, respectively, and have been expressed in natural logarithms.

The coefficient of determination is 0.90 using ordinary least-squares, 0.98 utilizing nonlinear least-squares, and 0.84 applying the logit procedure with weighted least-squares. In turn, the residual standard deviations, estimated as the sum of squares of the residuals divided by the number of observations, are 0.067, 0.066, and 0.067 in the three cases, respectively. 1/

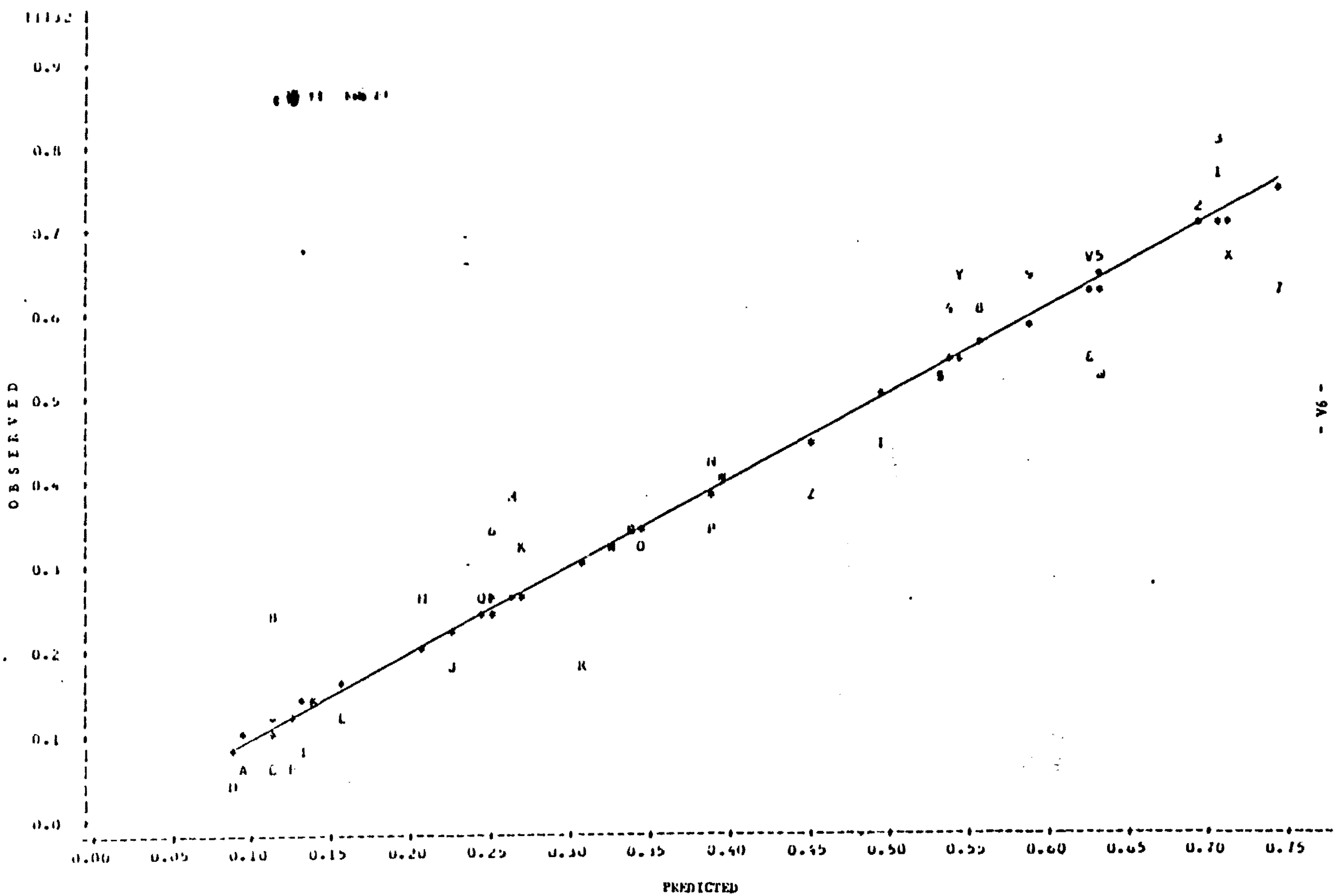
The plots obtained with the three alternative estimation procedures are also very similar and show uniformly small deviations from the regression line. Figure 1 provides the results under nonlinear least-squares estimation. As in the case of the other two methods of estimation, upward deviations are relatively more pronounced for India, Mexico, Austria and France while downward deviations are larger for Greece, Switzerland, and Germany. The deviations may be attributed to random errors rather than to economic causes; given their smallness, a formal analysis of the residuals has not been attempted.

Table 2 compares the results obtained in the Havrylyshyn-Civan study by ordinary least-squares with estimates derived using the same specification in the present study. The regression equations explain three-fourths of the variance of the index of intra-industry trade in both cases and, with one

1/ For a discussion on the comparability of goodness of fit measures, see the Technical Appendix.

Figure 1

Observed and Predicted Values of Intra-Industry Specialisation: Developed and Developing Countries.



Annex to Figure 1: List of Developed and Developing Countries

Name	Code	Per capita income ($)
Developed Countries		
Switzerland	@	6757.94
U.S.A.	&	6243.81
Sweden	9	6204.20
Denmark	8	5742.80
Germany	7	5621.63
Australia	6	5529.00
Canada	5	5526.22
Norway	4	4926.41
France	3	4837.30
Belgium	2	4758.45
Netherlands	1	4531.34
Japan	0	3840.09
Finland	Z	3758.26
Austria	Y	3673.65
U.K.	X	3301.83
Israel	W	3015.31
Italy	V	2583.86
Ireland	U	2253.67
Developing Countries		
Spain	T	2031.26
Singapore	S	1919.52
Greece	R	1887.30
Argentina	Q	1559.03
Hong Kong	P	1492.68
Portugal	O	1366.63
Yugoslavia	N	1031.82
Mexico	M	879.98
Brazil	L	778.24
Taiwan	K	659.48
Malaysia	J	634.57
Tunisia	I	506.48
Korea	H	391.74
Morocco	G	381.23
Turkey	F	291.05
Egypt	E	283.15
Thailand	D	268.85
Philippines	C	265.51
India	B	129.58
Pakistan	A	96.05

Note: The data refer to 1973 and have been expressed in U.S. dollars at the average exchange rate for that year.

Source: World Bank economic and social data bank.

exception, the statistical significance of the regression coefficients is also similar in the two studies. 1/

The per capita income variable and the dummy variables for the European Common Market and for the newly-industrializing countries are statistically significant at the 1 percent level whereas the domestic market variable is not significantly different from zero. However, while the variable for export concentration is significant at the 1 percent level in the Havrylyshyn-Civan study, it is not significantly different from zero in the present study. 2/

The high significance of the export concentration variable 3/ in the Havrylyshyn-Civan study can be explained by the fact that these authors included in the sample countries whose exports are dominated by a few primary export commodities. In fact, the export concentration variable and the per capita income variable, both representing the level of economic development, dominate the results, with a coefficient of determination of 0.62 for the two variables alone. This is hardly surprising since the Havrylyshyn-Civan study includes countries that have widely different economic structures, with a high extent of export concentration and a low share of manufactured exports being

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1/ Comparisons with the Loertscher-Wolter results are not meaningful as the latter used bilateral trade flows rather than each country's overall trade as observations. While this permitted testing for intercountry differences in per capita income and in market size, the coefficient of determination was only 0.15.

2/ Comparisons have not been made with the results obtained by Havrylyshyn-Civan in introducing dummy variables for the Latin American Free Trade Association and the Central American Free Trade Area, which were not significant at the 5 percent level in these authors' equations.

3/ This variable has been calculated by the use of the so-called Herfindahl index.

Table 2

Alternative Estimates of Intra-Industry Trade [a/]
(regression coefficients; ordinary least-squares)

	Havrylyshyn Civan [c/]		Present Study (1)		(2)		(3)		(4)	
Constant	0.1913	(3.44)	0.1702	(2.86)	0.0222	(0.38)	0.0120	(0.22)	0.0973	(1.78)
Proximity	-	-	-	-	0.0761	(2.37)	0.0935	(3.00)	0.1335	(4.62)
Border Dummy	-	-	-	-	0.1268	(3.02)	0.1154	(2.90)	0.0990	(2.83
Per Capita GNP [b/]	0.0038	(6.49)	0.0710	(7.04)	0.0619	(5.98)	0.0590	(6.01)	0.0390	(3.75)
GNP [b/]	0.0015	(0.08)	-0.0084	(0.91)	-0.0003	(0.04)	0.0021	(0.28)	0.0432[d]	(3.02)
Trade Orientation	-	-	-	-	0.1045	(2.84)	0.1076	(3.11)	0.1236	(4.04)
Export Concentration	-0.2343	(2.74)	-0.6517	(1.44)	-0.3656	(0.99)	-0.2997	(0.86)	-0.2398	(0.79)
EEC Dummy	0.2683	(5.29)	0.2247	(3.78)	0.1259	(2.31)	0.1177	(2.29)	0.0442	(0.87)
NIC Dummy	0.1668	(4.15)	0.0936	(1.98)	0.0723	(1.86)	0.0569	(1.53)	0.0226	(0.66)
Singapore Dummy	-	-	-	-	-	-	0.2063	(2.20)	0.3293	(3.62)
$\bar{R}^2$	0.7663		0.7397		0.8305		0.8503		0.8868	
N	62		38		38		38		38	

Notes: (a) For definition of variables, see text and Table 1
(b) Gross domestic product in the Havrylyshyn-Civan study
(c) For comparability with the present study the coefficient values have been divided by 100, with the exception of the per capita income variable where the same scaling was used in the two cases.
(d) Expressed in logarithmic terms.

associated with a low level of intra-industry specialization. Also, the choice made among low-income countries involves a considerable degree of arbitrariness, and the selection of a different set of countries might have given rise to different results. By contrast, the present study covers all countries that fulfil the stated criteria.

In turn, the poor performance of the domestic market variable (GDP in the Havrylyshyn-Civan investigation and GNP in the present study) is explained by its introduction in an untransformed form. As shown in Table 2, this variable is highly significant statistically if expressed in logarithmic terms, which compresses the extreme observations and reduces the variability of GNP that is quite large compared to the variability of the index of intra-industry trade.

At the same time, the level of statistical significance of the EEC and the NIC dummies declines if the proximity, border trade, and the Singapore dummy variables are introduced in the estimating equations of the present study. 1/ And, these dummy variables are not significant statistically at even the 10 percent level if the market size variable is expressed in logarithmic terms.

It appears, then, that the use of EEC and NIC dummies involves a misspecification as they pick up the statistical impact of other variables. This conclusion is of particular interest as far as the Common Market is concerned as it indicates that membership in the EEC adds little to the effects of proximity and border trade on intra-industry specialization when

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1/ The exclusion of the trade orientation variable does not change this result as this variable is uncorrelated with the other explanatory variables, it having been obtained from the residuals of equation (2).

the domestic market variable is expressed in logarithmic terms. It further appears that the NIC dummy largely picks up the impact of Singapore's entrepot trade.

Finally, the model specification of the present study has successfully included a policy variable in its effects on intra-industry specialization that is absent from the Havrylyshyn-Civan study. The results obtained with this variable indicate that increased openness, reflecting liberal trade policies, leads to greater intra-industry trade. At the same time, the specifications used in the present study have permitted explaining a higher proportion of the variance of the extent of intra-industry trade even though the countries under consideration represented a more homogeneous group than in the Havrylyshyn-Civan investigation.

IV

It has been noted that, in contradistinction with the Havrylyshyn-Civan investigation, this study has been limited to countries exporting manufactured products, thereby reducing the heterogeneity of the observations. It has further been noted that the inclusion of a dummy variable for developed and for developing countries has given poor statistical results. At the same time, interest attaches to making separate estimates for developed and for developing country subgroups.

The separation of developed and developing economies has been effected by taking their 1973 per capita incomes as the benchmark. Countries with per capita incomes of $2250 or higher have been classified as developed and countries with per capita incomes of $2030 or lower as developing, with no country being between these two benchmarks. 1/

The separation of the countries under study into two groups does not affect the explanatory power of the regression equation as represented by the coefficient of determination, under the nonlinear least squares procedure. For the developing country sample, this result obtains also under ordinary least squares estimation while the coefficient of determination is higher in this case if logit analysis with weighted least square is used. But the explanatory power of the regression is lower for the developed country sample under both the ordinary least squares and the logit procedures. 2/

In turn, the residual standard deviation is uniformly lower for the developing country sample and, to a much lesser extent, the developed country sample than for all countries taken together (Tables 1 and 3). At the same time, as explained in the Technical Appendix, it is the latter procedure rather than the coefficient of determination that permits comparisons of the goodness of fit under the different estimation procedures.

Notwithstanding the high explanatory power of the regression equations as countries exporting manufactured products have been divided into developed and developing country groups, increased intercorrelation among the explanatory variables and smaller variations in the values they take, have reduced the statistical significance of the individual regression

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1/ Cf. Annex to Figure 1.

2/ Clair, Gaussens, and Phan (1984) used ordinary least squares in an equation pertaining to intra-industry trade among developed countries. The explanatory power of the regression equation was approximately the same as in the present study.

Table 3

Estimation of Intra-Industry Trade for Developed and for Developing Countries Exporting Manufactured Products

	Developed Countries			Developing Countries		
	Ordinary Least Squares	Nonlinear Least Squares	Logit Analysis with Weighted Least Squares	Ordinary Least Squares	Nonlinear Least Squares	Logit Analysis with Weighted Least Squares
Constant	0.1276 (1.08)	-1.5872 (3.21)	-1.5141 (2.97)	0.2204 (3.99)	-1.3648 (3.21)	-1.2727 (2.83)
Proximity	0.1527 (2.41)	0.6236 (2.25)	0.6408 (2.28)	0.1414 (3.99)	0.6708 (3.02)	0.7021 (2.89)
Border Dummy	0.0268 (0.27)	0.1423 (0.33)	0.0880 (0.20)	0.0762 (2.25)	0.5787 (1.81)	0.5087 (1.64)
Per Capita GNP	0.1219 (1.55)	0.5254 (1.61)	0.4879 (1.45)	0.0198 (0.99)	0.1093 (0.74)	0.1388 (0.38)
GNP	0.0209 (0.80)	0.0813 (0.48)	0.0851 (0.76)	0.0917 (5.25)	0.5101 (4.22)	0.5438 (4.22)
Trade Orientation	0.2342 (1.25)	1.1302 (1.42)	0.9730 (1.21)	0.1485 (5.29)	0.9036 (4.10)	0.8891 (4.18)
Singapore Dummy	-	-	-	0.4570 (6.03)	2.205 (4.9[illegible])	2.2578 (4.60)
R^2	0.7340	0.9886	0.7463	0.8690	0.9681	0.9124
$\hat{\sigma}$	0.0643	0.0624	0.0645	0.0446	0.0489	0.0505
N	18	18	18	20	20	20

Note: See Table 1.

coefficients. This is the case, in particular, in the developed country group where the gross national product and GNP per capita are highly correlated and there is little variation in several of the other variables.

Thus, the domestic market variable is not significant in any of the equations estimated for the developed country group, and the statistical significance of the per capita income variable barely approaches 10 percent. And while the proximity variable is statistically significant at the 5 percent level in all the equations, the border variable is not significant at all. The latter result is explained by the fact that, apart from Australia and Japan, all developed countries have trading partners with common borders.

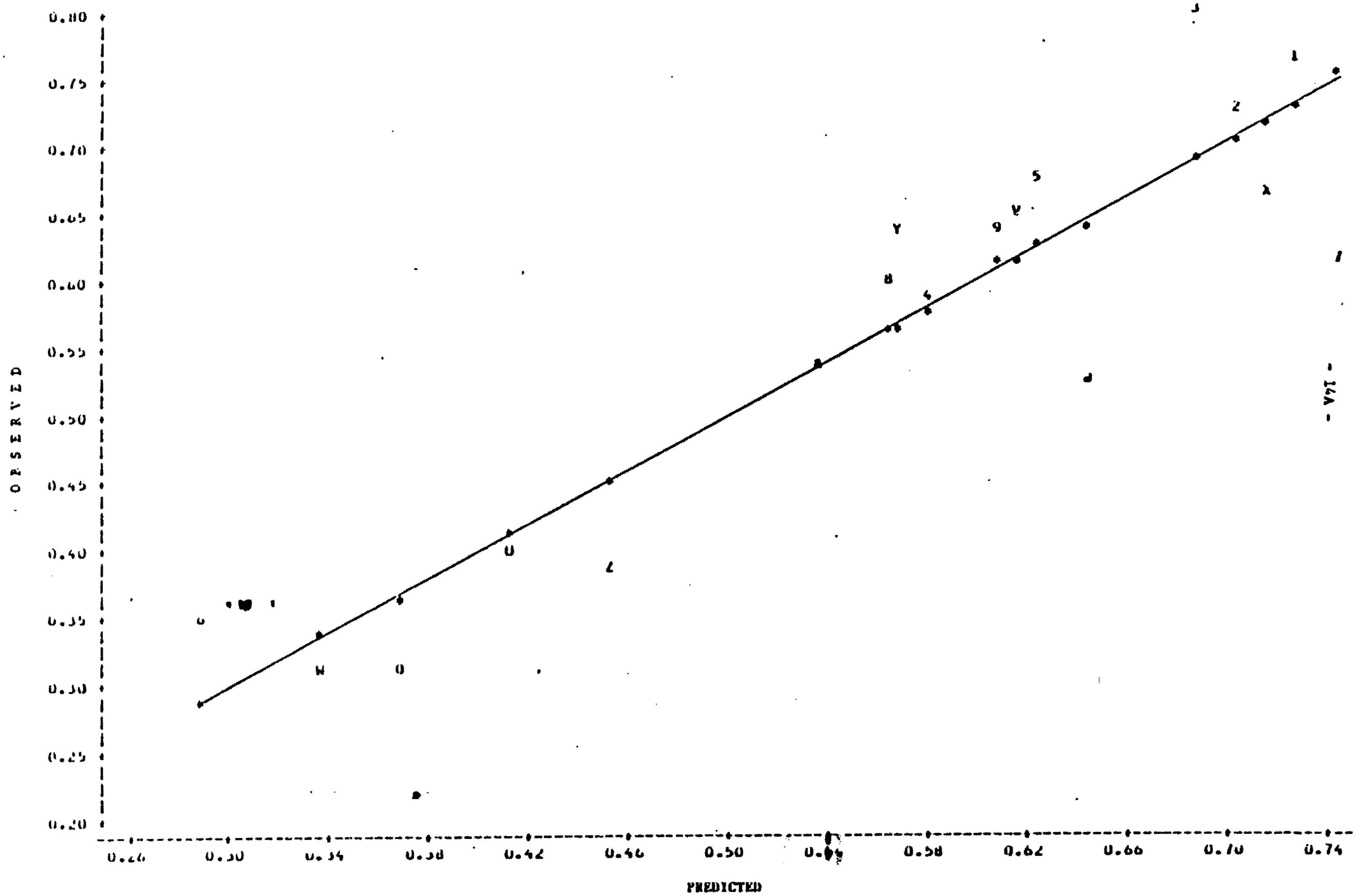
Finally, the trade orientation variable is not significant at the 10 percent level in the developed country equations. This result may be attributed to similarities among the developed countries as far as their trade orientation is concerned. With differences between actual and hypothetical values of per capita exports derived from equation (2) being relatively small, one cannot expect the trade orientation variable to be highly significant. 1/

By contrast, there are considerable variations among developing countries as far as their trade orientation is concerned, and this variable is statistically significant at the 1 percent level in all the equations. This is also the case for the proximity and the domestic market size variables and the Singapore dummy, while the per capita income variable is not significant at even the 10 percent level. Finally, the border dummy is statistically

1/ The standard deviation of the trade orientation variable, estimated from equation (2), is 0.19 for the developed country group and 0.62 for the developing country group.

Figure 2

Observed and Predicted Values of Intra-Industry Specialization: Developing Countries



significant at the 5 percent level in the equation estimated by ordinary least-squares and at the 10 percent level in the other two equations.

At the same time, using the results of logit estimation, the hypothesis that the regression coefficients, taken jointly, are equal in the developed country, the developing country, and the combined regression is not rejected at the 5 percent level. The same conclusion holds for the coefficients, taken individually, the exception being the GNP variable.

Finally, as shown in Figures 2 and 3, the observed values of the index of intra-industry trade are close to their estimated values for both the developed and the developing country groups. This is the case, in particular, for the developing country group, with larger than average deviations shown for Portugal and Mexico in the upward and for Spain in the downward direction.

The differences are somewhat greater in the developed country group, where Australia and France show relatively large deviations in the upward, and Germany and Switzerland in the downward, direction. The deviations appear to largely correspond to those observed in making estimates for all the countries under consideration and do not appear to have a particular economic rationale; rather they can be attributed to random variations.

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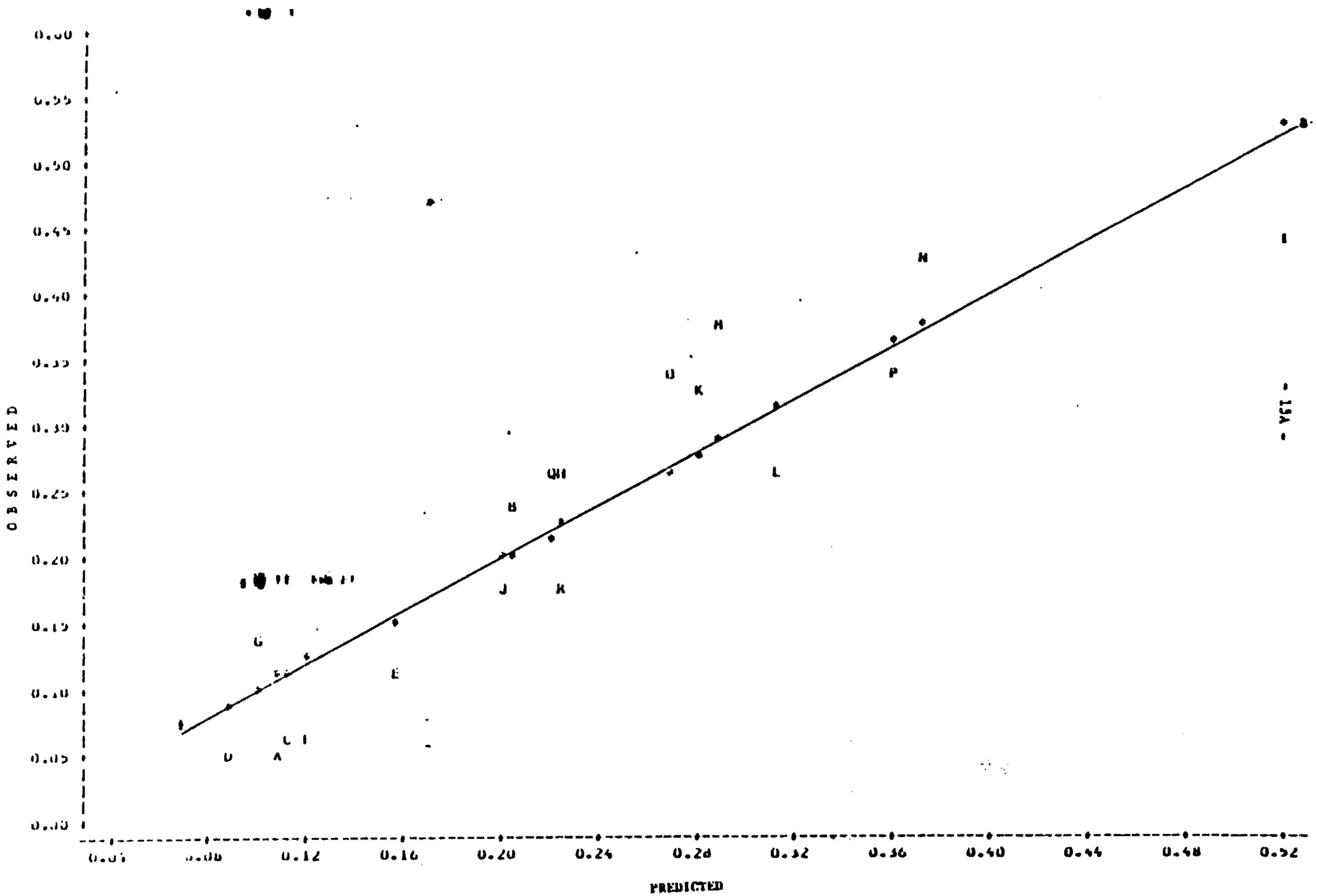
This paper has set out to explain intercountry differences in the extent of intra-industry trade in manufactured goods by reference to hypotheses derived from contributions to the theory of intra-industry trade. Apart from the effects of economic integration on intra-industry specialization, all the hypotheses put forward have been confirmed by the results and the explanatory power of the regression equation is high, irrespective of the estimating procedure used.

Figure 3
Observed and Predicted Values of Intra-Industry
Specialization: Developing Countries



First of all, the extent of intra-industry specialization increases with the level of economic development and the size of domestic markets. The existence of trading partners with common borders and geographical proximity also contribute to intra-industry trade and its role as an entrepot increases the extent of such trade in Singapore. Finally, intra-industry specialization is positively associated with the openness of national economies.

In turn, while according to the Havrylyshyn and Civan study participation in integration arrangements contributes to the explanation of intra-industry specialization, this does not appear to be the case if more appropriate specifications are introduced. Thus, defining the domestic market size variable in logarithmic terms, the newly industrializing country dummy loses its statistical significance if the Singapore dummy is included in the regression equation and the same fate befalls the Common Market dummy if allowance is made for border trade and geographical proximity that appear to be the dominant variables.

Estimates have further been made by separating the countries under study into developed and developing country groups. The explanatory power of the regression equations and the statistical significance of the coefficients in the developing country equations are again high. And while similarities in regard to trade orientation and the existence of border trade, as well as intercorrelation between the gross national product and per capita GNP, reduce the statistical significance of the regression coefficients of these variables for the developed country group, the equations have a relatively high explanatory power.

Some fifteen years ago, the author analysed the economic benefits of intra-industry trade through horizontal and vertical specialization, the former involving trade in different product varieties and the latter the international division of the production process (Balassa, 1967). Developing countries can increasingly obtain such benefits of intra-industry trade as they reach higher levels of economic development. At the same time, the results of the paper indicate that these benefits can be augmented through the liberalization of trade. The paper thus provides an additional argument for trade liberalization, in particular as far as developing countries are concerned.

Technical Appendix

..c Bauwens [1/]

Several alternative procedures have been tried to explain intercountry variations in the index of intra-industry trade (IIT) in the present study. This note discusses the choice of the functional form of the regression equation and methods of estimation utilized. It examines also the interpretation of the regression coefficients and the measures of goodness of fit under these procedures.

The index of intra-industry trade defined under (I) takes values between 0 and 1. There is no guarantee, however, that the predicted values of the regression equation will fall within this range when linear (I) or log-linear functions are used while such an outcome is ensured if a logistic function is chosen as in (II). [2/] The latter may also be transformed into (III), provided that the index of intra-industry trade is not exactly 0 or 1, which is the case for all the countries under consideration as indeed it is expected to be if the estimate pertains to individual countries. Under (III), the dependent variable (known as the logit of IIT) can vary between $-\infty$ and $+\infty$, and the regression equation is linear (in every case, x_j is defined as the vector of the explanatory variables).

(I) $IIT_j = \gamma' x_j$

1/ The author is Researcher at the World Bank.

2/ Other possible choices include the normal distribution function and the Gompertz curve, but they are not as convenient as the logistic function.

(II) $IIT_j = 1/(1+\exp-\beta' x_j)$

(III) $\ln(IIT_j/1-IIT_j) = \beta' x_j$

Despite its possible disadvantages, (I) has been estimated by ordinary least-squares (OLS) that has been used by several researchers on intra-industry trade. 1/ In turn, (II) has been estimated by the use of nonlinear least-squares (NLS) 2/, while (III) has been estimated by ordinary least-squares as well as weighted least-squares (WLS). The latter method has been recommended for minimum chi-square estimation of the logit model in the case of multiple observations. 3/ It has been applied by Loertscher and Wolter (1980) in the case of intra-industry trade, using $\sqrt{IIT_j\ (1-IIT_j)}$ to weight the explanatory variables. 4/ This method has also been used in this study, although questions arise about the theoretical justification for

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1/ In fact, the predicted values fall between 0 and 1 in the present study.

2/ It should be noted that, in this case, NLS is equivalent to the maximum likelihood estimation (MLE) of (II) under the assumption that the disturbances are normal. However, such an assumption would be highly questionable, since by construction the disturbances can only take values between -1 and +1. MLE could be performed by assuming that the disturbances have a truncated normal distribution, or a symmetrical beta distribution. Further research on this topic is in progress.

3/ In a model such as (III), IIT_j is an observed proportion, say n_j/m_j, where m_j is the number of observations corresponding to x_j, and n_j is the number of "successes". Then if m_j is large, the disturbance term of (III) has expectation 0 and variance $1/m_j \cdot IIT_j \cdot (1-IIT_j)$. The correction for heteroscedasticity thus requires dividing all the (dependent and explanatory) variables by the standard deviation of the disturbance and then applying OLS to the weighted data (Maddala, 1983, Chapter 2.8).

4/ However, they neglected to weight the dependent variable.

this form of heteroscedasticity in the present context, and the results obtained show little evidence of its existence.

Next, we indicate how to interpret and compare estimates of the coefficients under the different specifications. Let $D_{jk}(x)$ denote the partial derivative of IIT_j with respect to x_{jk} (the k-th variable of x_j), while $E_{jk}(x)$ denotes the corresponding elasticity. Then, under (I),

$$D_{jk}(x) = \gamma_k \;,\; E_{jk}(x) = \gamma_k x_{jk}/IIT_j,$$

while if $x_{jk} = \ln z_{jk}$,

$$D_{jk}(z) = \gamma_k/ z_{jk},\; E_{jk}(z) = \gamma_k/IIT_j$$

Under (II) and (III),

$$D_{jk}(x) = \beta_k\lambda_j \;,\; E_{jk}(x) = \beta_k\, x_{jk},$$

$$D_{jk}(z) = \beta_k\lambda_j/z_{jk},\; E_{jk}(z) = \beta_k,$$

where $\lambda_j = \exp -\beta' x_j/(1+\exp -\beta' x_j)^2.$

When a derivative or an elasticity depends on j, one can compute them at the sample mean of the relevant variables. 1/ This has been done in the following example, with comparisons made for elasticities of the regression results reported in Table 1, when a subscript * indicates that the elasticity was computed at the sample mean.

	OLS	NLS	LOGIT(WLS)	LOGIT(OLS)
proximity	0.361*	0.611	0.550	0.557
per capita GNP	0.156*	0.377	0.347	0.414
GNP	0.138*	0.204	0.219	0.249
trade orientation	0.023*	0.043*	0.048*	0.047*

Finally, we consider how to compare the goodness of fit of the different estimation methods. The R^2 is the natural measure in the case of OLS applied to specification (I). In the case of NLS, we compute the ratio of the sums of squares of the predicted values and of the dependent variable, but this ratio is not strictly comparable to the R^2 of OLS, because the sum of squares in the denominator is the variance of IIT in the case of OLS. For the logit specification (III) by OLS or WLS, the R^2's are not comparable with those of OLS and NLS, since the dependent variable is not the same; they are not comparable between logit by OLS and by WLS either because the dependent variable is weighted in the latter case but not in the former.

1/ An alternative method is to compute the sample mean of the derivatives or elasticities evaluated at the sample values.

An alternative procedure is to compare the four methods in terms of the standard deviation of the residuals of IIT. This standard deviation is obtained in a straightforward way in the cases of OLS with (I) and NLS with (II). In regard to (III), one has to use the estimates of β obtained by applying OLS or WLS to (III) in the right-hand side of (II) in order to compute the deviations between the two sides of (II). The resulting standard deviations will necessarily be greater than the standard deviation of OLS, since the latter method directly minimizes the sum of squares with respect to IIT, whereas the logit procedures minimize sums of squares with respect to the logit of IIT. The results are shown in Tables 1 and 3.

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