Bela Balassa and Luc Bauwens

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Comparative Advantage in Manufactured Goods in a Multi-Country, Multi-Industry, and Multi-Factor Model

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COMPARATIVE ADVANTAGE
IN MANUFACTURED GOODS
IN A MULTI-COUNTRY,
MULTI-INDUSTRY,
AND MULTI-FACTOR MODEL

by
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Abstract

The paper examines the determinants of trade among 38 principal exporters of manufactured goods in the framework of a multilateral trade model. The estimates provide support to the Heckscher-Ohlin theory of international specialization by showing that countries which are relatively abundant in physical and in human capital tend to export relatively physical and human capital intensive products in bilateral trade.

This conclusion does not depend on the choice of the estimation procedure or the specifications utilized. Thus, it is unaffected by the use of a two-stage or a one-pass procedure; estimation by linear or non-linear equations; the use of aggregated or disaggregated capital intensity; the measurement of capital intensity in stock or in flow terms; and the choice of the ratio or the difference form in defining relative capital endowments. The conclusion is also reconfirmed by estimates made for trade among developed countries and between developed and developing countries. This is not the case, however, with regard to trade among developing countries.

* *
1. In setting out to explain the pattern of international trade by interindustry differences in factor intensities and intercountry differences in factor endowments, the Heckscher-Ohlin theory posits the existence of a well-defined relationship among trade flows, factor intensities, and factor endowments. In his *Sources of International Comparative Advantage: Theory and Evidence*, Edward E. Leamer suggests that “the way to measure the accuracy of the theory is to obtain direct and independent measures of all three concepts ...” (1984, p. 49).

Rather than introducing all three elements in their empirical investigation, a long list of researchers, including Baldwin (1971 and 1979), Branson (1973), Stern (1976), Branson and Monoyios (1977), Harkness (1978), Stern and Maskus (1981), Maskus (1983), and Urata (1983), attempted to infer the relative factor endowments of a single country vis-a-vis the rest of the world from the factor intensity of its trade. This procedure is open to several objections, however.

There are obvious inadequacies in testing the Heckscher-Ohlin theory from the data of a single country. This will be the case, in particular, if the country is an “outlier”. In fact, apart from Stern (Germany) and Urata (Japan), the country chosen in every case was the United States. While this choice might have been dictated by data availability and by the desire to provide an explanation for the Leontief paradox, the United States may represent a special case.

Moreover, as Leamer and Bowen (1981) first showed by means of a three-dimensional example, the inference made about factor endowments from a cross-section regression of trade flows on factor intensities may be incorrect. Subsequently, Aw (1983) proved in the framework of a multi-country and multi-industry model that inferences about relative factor abundance from cross-section results in regard to the trade of a particular country cannot be made, unless very stringent conditions are met.

An alternative approach, utilized by Leamer (1974), Bowen (1983), and, again, Leamer (1984), attempts to test the Heckscher-Ohlin theory by relating trade flows to factor endowments. But, as Bowen as well as Leamer admit, there is no necessary relationship between the coefficients estimated in regard to factor endowments and the factor intensity of trade. Correspondingly, this method will not be appropriate to test the Heckscher-Ohlin theory either.

The described deficiencies of the procedures commonly utilized for testing the Heckscher-Ohlin theory were overcome in an earlier study by the senior author, who simultaneously introduced trade flows, factor
intensities, and factor endowments in analyzing the pattern of comparative advantage in manufactured goods (Balassa, 1979). Estimation was carried out by the use of a two-stage procedure.

In the first stage, indices of relative export performance vis-a-vis the rest of the world, calculated for individual industries, were regressed on measures of total (physical and human) capital intensity for each of 36 major exporters of manufactured goods. In the second stage, the regression coefficients thus obtained, indicating the relative capital intensity of the export structure of the individual countries, were regressed on the physical and human capital endowments of the countries concerned in a cross-section framework.

In transposing results obtained in “commodity space” into “country space”, the method applied provided a test of the Heckscher-Ohlin theory by introducing factor endowments along with factor intensities in the process of estimation. In a subsequent paper, estimates were also made for the imports of manufactured goods and for net exports; total capital intensity was disaggregated into physical and human capital intensity; and an estimation technique combining the two stages in a “one pass” procedure was utilized (Balassa, 1984).

In these two papers, trade in particular industries of the individual countries with the rest of the world was the unit of observation. The present paper extends the investigation to a multi-country context by examining the determinants of the network of trade among 38 principal exporters of manufactured goods; i.e. it replaces a vector by a matrix of trade. This involves gauging the effects of relative factor endowments on the factor intensity of bilateral trade flows, defined in terms of net exports, in the framework of a multilateral model.

As in the earlier investigations, three factors of production are introduced in the analysis: physical capital, human capital, and unskilled labor. Factor intensities are expressed in terms of physical capital per worker and human capital per worker, with calculations made using aggregated as well as disaggregated measures of capital intensity. Factor endowments are defined in a comparable manner, in terms of the stock of physical capital and the stock of human capital. The investigation

\[1\] According to Leamer (1984), the three variables were introduced simultaneously in an unpublished paper by Bowen, Leamer, and Sveikauskas (1982). This paper, written several years after the publication of the study referred to above, has not been available to the authors of the present paper.
covers altogether 167 industries, with the exclusion of natural resource intensive products.

Section II of the paper describes the methodology applied while Section III provides information on the data used in the investigation. Section IV reports on the empirical results obtained for trade among all the countries concerned. In turn, Section V describes the results pertaining to trade among developed countries, among developing countries, and between developed and developing countries.

2. The methodology applied involves two-stage as well as one-pass estimation. These will be taken up in turn. In both cases, aggregated capital intensities are introduced first, followed by their disaggregation into physical and human capital.

Two-Stage Estimation

In the first stage of estimation, standardized values of net bilateral exports are regressed on capital-labor ratios; in the second, the resulting regression coefficients for bilateral trade are regressed on relative country endowment variables. The two stages of estimation are expressed in (1) and (2) for the case when physical and human capital intensities are aggregated and in (3) and (4) for the case when they are separately introduced.

Aggregated Capital Intensities

(1) \( NNX_{jki} = a_j \beta_{jk}^c \ln c_i + u_{jki} \)

(2) \( \beta_{jk}^c = a^c + b^c \ln \frac{G_j}{G_k} + d^c \ln \frac{H_j}{H_k} + v_{jk}^c \)

Disaggregated Capital Intensities

(3) \( NNX_{jki} = a_j \beta_{jk}^p \ln p_i + \beta_{jk}^h \ln h_i + u_{jki} \)

(4) (a) \( \beta_{jk}^p = a^p + b^p \ln \frac{G_j}{G_k} + v_{jk}^p \)

(b) \( \beta_{jk}^h = a^h + b^h \ln \frac{H_j}{H_k} + v_{jk}^h \)
In the equations, $NNX$ stands for normalized net exports; $c$ refers to total (aggregate) capital intensity; $p$ and $h$ denote physical and human capital intensities, respectively; and $G$ and $H$ are the physical and human capital endowment variables. In turn, $j(1...38)$ and $k(1...37)$ are the country subscripts and $i(1...167)$ is the industry subscript.

Since $NNX_{jk} = -NNX_{kj}$, in the model incorporating trade among all the countries under consideration there are potentially 703 ($jk/2$) equations pertaining to bilateral trade between pairs of countries in the first stage of estimation; in each equation there are potentially 167 observations. In fact, there are fewer numbers of equations and of non-zero observations, because of the lack of trade flows between certain pairs of countries in some or all industries. Altogether, 639 first-stage equations have been estimated, with 67,989 observations as compared to a potential number of 117,401; correspondingly, there are 639 observations in estimating the second-stage equation.

(1) and (3) modify the equational forms used in the earlier papers as the data now pertain to bilateral trade rather than to the trade of each country with the rest of the world. Regression coefficients $\beta_p^j$ in (1) and $\beta_p^k$ and $\beta_h^j$ in (3) thus show the estimated relationship between the pattern of net exports between countries $j$ and $k$ and the capital intensities of the individual industries.

In (2) and (4), intercountry differences in physical and human capital endowments are introduced to explain the pattern of the $\beta$-coefficients estimated in (1) and (3), respectively. In (2), this involves linking the total (physical and human) capital intensity of bilateral trade to relative physical and human capital endowments; in (4) the physical capital intensity of bilateral trade is linked to relative physical capital endowments and the human capital intensity of bilateral trade to relative human capital endowments. The hypothesis is tested that countries which are relatively capital abundant will tend to export relatively capital intensive products in bilateral trade.

We have experimented with alternative definitions of relative capital endowments. One alternative, shown in (2) and (4), involves using the ratio of capital endowments in countries $j$ and $k$, expressed in logarithmic terms, that is equivalent to differences in logs. Another alternative

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2An attempt has been made to introduce cross-terms in equation (4) by adding $H_j/H_k$ in (4a) and $G_j/G_k$ in (4b). Due to the multi-collinearity of the factor endowment variables, statistically significant results have not been obtained.
involves using absolute differences in factor endowments \((G_j - G_k)\) and \((H_j - H_k)\) instead.

In most instances, the choice between the two alternatives has not affected the statistical significance of the regression coefficients, indicating the robustness of the results to the specification of relative capital endowments. In the equations where this was not the case, the absolute difference form has generally worked better. Both sets of results are reported in the tables.

Ordinary least squares have been used in estimating (1) and (3). In order to adjust for heteroskedasticity, weighted least squares have been used in estimating (2) and generalized least squares in estimating (4). In the latter case, (4a) and (4b) have been simultaneously estimated.

**One-pass Estimation**

The one-pass procedure combines the two stages of estimation, involving the use of interaction terms that relate capital intensities to capital endowments. Combining (1) and (2) yields (5) while combining (3) and (4) yields (6).

\[
(5) \quad NNX_{jki} = a_{jk} + a^c \ln c_i + b^c \ln \frac{G_j}{G_k} \ln c_i + c^c \ln \frac{H_j}{H_k} \ln c_i + \varepsilon_{jki},
\]

where \(\varepsilon_{jki} = v^c_j \ln c_i + u_{jki}\)

\[
(6) \quad NNX_{jki} = a_{jk} + a^p \ln p_i + b^p \ln \frac{G_j}{G_k} \ln p_i + c^p \ln \frac{H_j}{H_k} \ln p_i + \varepsilon_{jki},
\]

where \(\varepsilon_{jki} = v^p_j \ln p_i + v^h_j \ln h_i + u_{jki}\)

Comparisons of (2) and (5) and of (4) and (6) show that one can interpret the coefficients of \(\ln c_i, \ln p_i,\) and \(\ln h_i\) in one-pass estimation as
the constants of the second stage equation, and the coefficients of \( \frac{G_j}{G_k} \ln c_i \) and \( \frac{H_j}{H_k} \ln c_p \), as well as those of \( \frac{G_j}{G_k} \ln p_i \) and \( \frac{H_j}{H_k} \ln h_j \), as the coefficients of \( \frac{G_j}{G_k} \) and \( \frac{H_j}{H_k} \) in the second-stage equation.

Under certain assumptions, the two sets of estimated coefficients will have equal values (Amemiya, 1978); however, their levels of statistical significance will differ, owing to differences in the number of observations.

(5) and (6) are expressed in linear terms. Another alternative involves utilizing a non-linear function as in (7) where \( \gamma' \bar{z}_{jki} \) stands for the variables included in the model to be estimated; i.e. the right-hand side of (5) and (6) with the exclusion of the error term. This has been derived from

\[
(7) \quad \bar{N}N_X_{jki} = \frac{1 - \exp - (\gamma' \bar{z}_{jki})}{1 + \exp - (\gamma' \bar{z}_{jki})} + \varepsilon_{jki}
\]

the logistic function \( y = 1/(1 + \exp - t) \), where \( 0 \leq y \leq 1 \), utilizing the transformation \( x = 2y - 1 \). Thus,

\[-1 \leq x = \frac{2}{1 + \exp - t} - 1 = \frac{1 - \exp - t}{1 + \exp - t} \leq 1\]

Estimation by non-linear least squares has the advantage of limiting the predicted values of the dependent variable to the range \((-1, +1)\), which is the range of the actual values of this variable. Also, it is not necessary to include the country specific interaction term \( a_{jk} \), the estimation of which would be costly and difficult as there are 639 such terms. In view of these advantages of non-linear least squares, and the existence of considerable similarities between the two sets of estimates, the results obtained by ordinary least squares are not reported in the tables; the estimates are available from the authors.

3. As noted above, the data used in the investigation include normalized net exports for trade between countries \( j \) and \( k \) in industries \( i \); physical and human capital-labor ratios for the \( i \) industries; and physical and human capital endowments for the \( j \) countries. These will be considered in turn.

Net exports have been normalized in order to eliminate the effects of intercountry differences in the volume of trade in manufactured goods. Normalization has been done by dividing the net exports of each industry
in trade between countries \( j \) and \( k \) by the sum of these exports and imports as in (8); while normalization by the use of production data would have been preferable, such data are not available.

\[
(8) \quad NNX_{jki} = \frac{(X_{jki} - M_{jki})}{(X_{jki} + M_{jki})}
\]

Physical and human capital intensity have been defined as physical capital per worker and human capital per worker.\(^3\) Investment in research and development has been subsumed under these two; it is in part embodied in physical capital (e.g. laboratories) and in part in human capital (scientists engaged in R&D). The application of this procedure will be appropriate in an investigation of the changing pattern of comparative advantage in the process of economic development as developing countries engage in research and development to a limited extent, if at all.

Physical as well as human capital intensity have been defined in terms of both stocks and flows. The stock measures of physical and human capital intensity are the value of the physical capital stock divided by the number of workers and the discounted value of the difference between the average wage and the unskilled wage,\(^4\) respectively; the flow measures are non-wage value added per worker and the difference between the average wage and the unskilled wage.

The two measures of human capital intensity are identical, except for a scalar that is the assumed rate of return on human capital. The same conclusions will hold for physical capital intensity only if certain conditions are fulfilled: the economy is in risk-free equilibrium; product, capital, and labor markets are perfect; and non-wage value added includes only the remuneration of capital.\(^5\)

These conditions are not fulfilled in practice. Production is subject to risks that vary among industries and, if producers are risk-avers, profit rates will include a risk premium that may differ among industries.

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\(^3\) For a detailed discussion of the estimation of physical and human capital intensity and the endowments of physical and human capital, with references to earlier work, see Balassa, 1979.

\(^4\) As in the earlier papers, a discount rate of 10 percent has been applied to a constant earnings stream.

\(^5\) There may also be differences in the rate of return on human and physical capital if, for example, investment in human capital generates psychic returns.
Nor will the situation in a particular year represent an equilibrium position. Furthermore, industries experience imperfections of varying magnitudes in product, capital and labor markets. Finally, non-wage value added includes items other than remuneration of capital, such as advertising.

The existence of interindustry differences in regard to risk, market imperfections, and the inclusion of items other than capital's remuneration in non-wage value added, as well as variations in profit rates over time, give rise to error possibilities in the use of the flow measure of physical capital intensity. In turn, the use of historical rather than replacement values for physical assets, together with interindustry differences in accounting depreciation rates, are sources of error in the use of the stock measure of physical capital.

In order to test the stability of the results, estimates have been made by utilizing the stock as well as the flow measure of capital. Following the earlier studies by the senior author (1979 and 1984), data derived from U.S. statistics have been used in the investigation. As is well-known, this will be appropriate if factor-substitution elasticities are zero or they are invariant among industries. The nonfulfilment of this assumption introduces error possibilities in the estimation without, however, necessarily biasing the results.

The point of departure in establishing the industry classification scheme has been the definition of the manufacturing sector (SIC 19 to 35) in the US Standard Industrial Classification (SIC). Next, we have excluded natural resource products whose manufacture is importantly affected by the availability of natural resources in a particular country. Six-digit categories have been combined in cases when the economic characteristics of the product in question have been judged to be very similar or comparable data did not exist according to the U.N. Standard International Trade Classification, which has

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6The 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.

7The principal criteria have been high substitution elasticities in production and consumption.
been used to collect the trade figures. Altogether 167 products categories have been utilized.

Data on the capital stock, employment, value added, and wages used in calculating capital intensity originate from the U.S. Census of Manufacturing and are averages for the years 1969 and 1970. Data on unskilled wages for the same period have been taken from the *Monthly Labor Review*, published by the US Department of Labor, Bureau of Labor Statistics; they relate to the 2-digit industry group, thus involving the assumption that unskilled wages are the same within each 2-digit group.

The trade data used in the investigation pertain to 1971. They have been obtained from the GATT tapes. The commodity classification scheme employed requires the use of trade data down to the 5-digit level. In a few cases when 5-digit data were not available, they have been estimated from the 4-digit data on the basis of the worldwide composition of trade.

The study covers altogether 38 countries whose manufacturing exports exceeded $300 million, and accounted for at least 18 percent of their total exports, in 1979. The group includes 18 developed countries with per capita incomes of $2,253 or higher and 20 developing countries with per capita incomes of $2,031 or lower in 1979.

The sum of gross fixed investment over the seventeen year period between 1954 and 1970, estimated in constant prices and converted into US dollars at 1967 exchange rates, has been used as a proxy for physical endowment for the countries concerned. Investment values have been assumed to depreciate at an annual rate of 4 percent a year, reflecting the obsolescence of capital, with capital equipment having a useful life of 17 years. The relevant information has been obtained from the World Bank economic and social data base, and the estimates have been expressed in per capita terms.

The Harbison-Myers index of education has been used as a proxy for human capital. The index is derived as the secondary school enrollment rate plus five times the university enrollment rate, both calculated in their respective age cohorts. This index is a flow measure and estimates pertaining to 1965 have been utilized as an indicator of a country's general educational level, and thus its human capital base, in 1971.

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8 The year 1979 has been chosen as a benchmark in order to include countries with a potential to export manufactured goods.
Tables 1 and 2, respectively, report the estimates made by the use of the two-stage and the one-pass procedures for trade among all the countries included in the investigation. The tables show estimates obtained by using aggregated and disaggregated capital intensity variables; stock and flow measures of capital; and relative capital endowment variables expressed in terms of ratios and absolute differences.

In the estimated equations, the regression coefficients of the relative capital endowment variables have the expected sign and, with one exception, are statistically significant at the one percent level. The sole exception is the human capital endowment variable in the case when capital intensities are aggregated, relative capital endowments are expressed in a ratio form, and the stock measure of capital intensity is used.

The constants of the equations are statistically significant in all cases when capital intensities are aggregated. This result was also obtained in estimation by the use of the disaggregated form of capital intensity for the constants pertaining to human, but not to physical, capital.

It further appears that the explanatory power of the regression equations is greater in the event that capital intensities are aggregated rather than disaggregated. Thus, the coefficient of determination is in the 0.60-0.62 range in the first case and in the 0.42-0.48 range in the second. In each case, the adjusted $R^2$s are practically the same, irrespective of whether the stock or the flow measure of capital intensity is used when capital is aggregated while the use of the flow measures gives a higher $R^2$ if capital is disaggregated. Finally, the coefficient of determination is not affected by the choice of the ratio and the difference form of relative capital endowments.

One-pass estimation by non-linear least squares does not permit deriving the coefficient of determination. But, all the regression coefficients are statistically significant at the 1 percent level in every equation, irrespective of the specification applied, with the t-values ranging between 4.8 and 46.8. At the same time, the constant terms pertaining to the physical capital endowment variable that were not significant statistically under two-stage estimation have a negative sign under one-pass estimation.

In demonstrating that the factor intensity of bilateral trade in manufactured goods can be explained in terms of relative factor endowments, the empirical results of the paper provide support to the Heckscher-Ohlin theory of comparative advantage. This conclusion obtains under several alternative specifications and utilizing a two-stage as well as a one-pass estimation procedure, with the latter procedure generally
providing stronger results in terms of the statistical significance of the regression coefficients.

The estimates made under alternative specifications also indicate the appropriateness of aggregating physical and human capital. While this result contrasts with that obtained by several authors (Branson, 1973; Stern, 1976; Branson and Monoyios, 1977; and Stern and Maskus, 1981), in the latter studies differences in the signs of physical and human capital were shown for two industrial countries, the United States and Germany; by contrast, in the present study, estimates were made for multilateral trade. At any rate, as noted in Section 1 above, the interpretation of the results obtained by these authors is open to question, because capital endowments are inferred from results pertaining to capital intensities.

5. Estimates have further been made for trade among the developed countries, for trade between developed and developing countries, and for trade among developing countries. Tables 3 to 5 report the estimates made by the use of the two-stage procedure in the three cases.

The estimates reported in Table 3 for trade among developed countries generally confirm the results obtained for trade among all the countries under consideration. The explanatory power of the two sets of regressions is very similar, except that the use of the flow measure of capital intensity now gives lower coefficients of determination if capital is disaggregated.

In the estimates made for trade among developed countries, the regression coefficients of the relative capital endowment variables are significant at the 1 percent level in all cases where capital intensities are aggregated. The same result obtains in cases where capital intensity is introduced in a disaggregated form, except that the physical capital endowment variable is not statistically significant at even the 10 percent level when the flow measure of capital intensity is used. At the same time, the levels of significance of the constants of the regression equations vary, depending on the specifications used.

The coefficients of determination are by far the highest in the case of estimates for trade between developed and developing countries (Table 4); they are around 0.75 in cases when capital intensities are aggregated and 0.65 when capital intensities are disaggregated, with little variation shown in the estimates. The high degree of explanatory power of the regressions estimated for trade between developed and developing countries may be explained by the exclusion of trade among developing
countries, where intercountry differences in factor endowments have a low explanatory power as noted below.

In estimates made for trade between developed and developing countries, the regression coefficients of the physical capital endowment variable are statistically significant at the 1 percent level in all the equations. In turn, the level of significance of the human capital endowment variable depends on whether relative capital endowments are introduced in a ratio or in a difference form. While the regression coefficients are significant at the 5 percent or, at least at the 10 percent, level in the latter case, they are not statistically in the former case. Finally, the statistical significance of the constants of the regression equations again varies depending on the specifications used.

The coefficients of determination do not reach 0.1, and few of the regression coefficients are statistically significant, in the estimates made for trade among developing countries (Table 5). And, in the cases when the physical capital endowment variable is statistically significant at the 5 percent level, the human capital endowment variable is not significant.

It would appear, then, that the Heckscher-Ohlin theory, which well explains trade in manufactured goods among all the principal countries exporting these commodities, among developed countries, as well as between developed and developing countries, fails to provide an explanation for trade in manufactured goods among the developing countries. While this, negative, result requires further study, some possible explanations may be put forward.

A contributing factor may have been the poor quality of the data. To begin with, trade data for the developing countries involve considerable error, in particular as far as their geographical composition is concerned. Also, the use of US input coefficients will introduce greater error possibilities in calculations made for developing than in those for developed countries. Finally, estimates of factor endowments for developing countries, based on cumulated investment data that are themselves subject to uncertainty, are subject to greater errors than the estimates for developed countries.

An additional consideration is that the variability of industrial protection is substantially greater in developing than in developed countries. Apart from the results of effective protection studies, this conclusion is confirmed by estimates of the senior author who measured the extent of trade orientation in terms of deviations of actual from predicted exports per head, the latter being derived from a cross-section regression equation incorporating per capita income, population, mineral exports, and dis-
tance as explanatory variables. The results show that the standard
deviation of the residuals is three times as high for developing than for
developed countries (Balassa, 1984).

The idiosyncracies of the pattern of industrial protection in developing
countries would weaken the effects of differences in factor endowments
on trade in manufactured goods among developing countries. A further
distorting factor is the existence of preferential arrangements among
developing countries, in particular, in Latin America. In fact, there is
evidence that such arrangements have led to considerable deviations
from the pattern of comparative advantage in trade among the LAFTA
countries (Krueger, 1983, ch. 6).

6. This paper has set out to test the Heckscher-Ohlin theory of inter-
national specialization in a model that includes trade flows, factor
intensities, and factor endowments. In this way, it has been possible to
provide a rigorous test of the theory, which was not the case in contrib-
utions by other authors who attempted to infer factor endowments
from data on trade flows and factor intensities or factor intensities from
data on trade flows and factor endowments.

The paper has used a multilateral trade model to explain the pattern
of bilateral trade in manufactured goods among major exporters of
the products by reference to interindustry differences in factor intensities
and intercountry differences in factor endowments. This has been
accomplished by utilizing a two-stage as well as a one-pass procedure.
In the former case, standardized net exports are regressed on measures
of capital intensity for each pair of countries and the regression coef-
ficients thus obtained are regressed on relative capital intensity in a cross
section framework; in the latter case, the two stages of estimation are
combined into one.

The results obtained for trade among the 38 principal exporters of
manufactured goods provide support to the Heckscher-Ohlin theory:
they show that countries which are relatively abundant in physical and
in human capital tend to export relatively physical and human capital
intensive commodities in bilateral trade. This conclusion does not depend
on the choice of the estimation procedure or on the specifications utilized.
Thus, it is unaffected by the use of a two-stage or one-pass procedure,
estimation by linear or non-linear equations, the use of aggregated or
disaggregated capital intensity, the measurement of capital intensity in
stock or in flow terms, and the choice of the ratio or the difference form
in defining relative capital endowments.
The conclusion is reconfirmed by estimates made for trade among developed countries as well as for trade between developed and developing countries. At the same time, while in the former case intercountry differences in both physical and human capital endowment affect the results, in the latter case comparative advantage is determined largely by physical capital endowments. Finally, the Heckscher-Ohlin theory has not been successfully tested with regard to trade among developing countries. In the latter case, data limitations, the variability of industrial protection, and preferential arrangements appear to have affected the results.
<table>
<thead>
<tr>
<th>Definition of Intercountry Differences in Capital Endowment</th>
<th>Stock Flow</th>
<th>a^S</th>
<th>a^F</th>
<th>b^c</th>
<th>(d^c)</th>
<th>b^g</th>
<th>b^h</th>
<th>R^2</th>
<th>N</th>
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<td></td>
<td>F</td>
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<td>0.126</td>
<td>0.034</td>
<td>(10.51)**</td>
<td>(2.89)**</td>
<td>0.6015</td>
<td>639</td>
<td></td>
</tr>
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<td>0.608</td>
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<td>0.6186</td>
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<td>0.041</td>
<td>0.609</td>
<td>0.105</td>
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<td>0.6224</td>
<td>639</td>
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<tr>
<td>ratio (b)</td>
<td>S</td>
<td>0.000</td>
<td>0.137</td>
<td>0.064</td>
<td>0.069</td>
<td></td>
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<td>0.4167</td>
<td>1264</td>
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<tr>
<td></td>
<td>F</td>
<td>0.002</td>
<td>0.136</td>
<td>0.087</td>
<td>(12.50)**</td>
<td>(6.49)**</td>
<td>0.4817</td>
<td>1264</td>
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<tr>
<td>difference (c)</td>
<td>S</td>
<td>0.008</td>
<td>0.132</td>
<td>0.298</td>
<td>0.084</td>
<td></td>
<td></td>
<td>0.4591</td>
<td>1264</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.015</td>
<td>0.129</td>
<td>0.399</td>
<td>(12.48)**</td>
<td>(8.84)**</td>
<td>0.4775</td>
<td>1264</td>
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</tr>
</tbody>
</table>

(a) For explanation of symbols, see text.
Note: levels of statistical significance of 1, 5 and 10 percent, derived in two-tail tests, are denoted by "**, *, and A, respectively.
(b) ln \(\frac{C_i}{C_e} \ln \frac{H_j}{H_e}\)
(c) \(G_i-C_i, (H_j-H_e)\)
### Table 2
Explanation of Intercountry Differences in the Pattern of Specialization in Manufactured Goods in the Multilateral Framework: Trade Among All Countries (a) (logistic estimates of the one-pass model, with t-values in parenthesis)

<table>
<thead>
<tr>
<th>Stock Flow</th>
<th>(a^c)</th>
<th>(a^b)</th>
<th>(a^a)</th>
<th>(b^c)</th>
<th>(b^b)</th>
<th>(b^a)</th>
<th>(c^2)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>ratio (^b)</td>
<td>S</td>
<td>0.027</td>
<td>0.125</td>
<td>0.027</td>
<td>(8.48)^*</td>
<td>(6.31)^*</td>
<td>0.15654</td>
<td>67989</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.028</td>
<td>0.136</td>
<td>0.029</td>
<td>(8.70)^*</td>
<td>(6.92)^*</td>
<td>0.15695</td>
<td>67989</td>
</tr>
<tr>
<td>difference (^c)</td>
<td>S</td>
<td>0.005</td>
<td>0.113</td>
<td>0.016</td>
<td>(18.83)^*</td>
<td>(4.81)^*</td>
<td>0.16135</td>
<td>67989</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.005</td>
<td>0.107</td>
<td>0.017</td>
<td>(18.99)^*</td>
<td>(4.94)^*</td>
<td>0.16169</td>
<td>67989</td>
</tr>
<tr>
<td>ratio (^b)</td>
<td>S</td>
<td>0.109</td>
<td>0.116</td>
<td>0.020</td>
<td>(9.73)^*</td>
<td>(6.31)^*</td>
<td>0.15322</td>
<td>67989</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.149</td>
<td>0.211</td>
<td>0.038</td>
<td>(16.26)^*</td>
<td>(7.86)^*</td>
<td>0.15593</td>
<td>67989</td>
</tr>
<tr>
<td>difference (^c)</td>
<td>S</td>
<td>0.074</td>
<td>0.132</td>
<td>0.022</td>
<td>(6.64)^*</td>
<td>(5.69)^*</td>
<td>0.16013</td>
<td>67989</td>
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<tr>
<td></td>
<td>F</td>
<td>0.110</td>
<td>0.214</td>
<td>0.024</td>
<td>(8.70)^*</td>
<td>(6.28)^*</td>
<td>0.16066</td>
<td>67989</td>
</tr>
</tbody>
</table>

(a) For explanation of symbols, see text.
(b) \(\ln G_j - \ln H_j\)
(c) \((G_j - G_k), (H_j - H_k)\)
### TABLE 3

Explanation of Intercountry Differences in the Pattern of Specialization in Manufactured Goods in the Multilateral Framework: Trade Among Developed Countries (a)
(WLS and GLS estimates of two-stage model, with t-values in parenthesis)

<table>
<thead>
<tr>
<th>Definition of Intercountry Differences in Capital Endowment</th>
<th>Stock Flow</th>
<th>( g^a )</th>
<th>( b^a )</th>
<th>( a^1 )</th>
<th>( b^1 )</th>
<th>( a^2 )</th>
<th>( b^2 )</th>
<th>( b^h )</th>
<th>( R^2 )</th>
<th>( N )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ratio</strong> ( h )</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.075</td>
<td>0.197</td>
<td>0.349</td>
<td>0.0628</td>
<td>153</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>(1.38)</td>
<td>(5.88)**</td>
<td>(8.28)**</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>F</td>
<td>0.084</td>
<td>0.140</td>
<td>0.283</td>
<td>0.6055</td>
<td>153</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(2.69)**</td>
<td>(4.10)**</td>
<td>(9.28)**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Difference</strong> ( c )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>S</td>
<td>0.019</td>
<td>0.478</td>
<td>0.151</td>
<td>0.0346</td>
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<tr>
<td>(1.20)</td>
<td>(6.46)**</td>
<td>(9.61)**</td>
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<tr>
<td>F</td>
<td>0.036</td>
<td>0.360</td>
<td>0.167</td>
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<tr>
<td>(2.27)**</td>
<td>(4.81)**</td>
<td>(10.53)**</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ratio</strong> ( h )</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>S</td>
<td>-0.016</td>
<td>0.070</td>
<td>0.151</td>
<td>0.148</td>
<td>0.4240</td>
<td>306</td>
<td></td>
<td></td>
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<tr>
<td>(1.22)</td>
<td>(7.94)**</td>
<td>(5.54)**</td>
<td>(6.84)**</td>
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<td></td>
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<tr>
<td>F</td>
<td>0.039</td>
<td>0.069</td>
<td>0.045</td>
<td>0.136</td>
<td>0.3451</td>
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<tr>
<td>(2.26)**</td>
<td>(7.30)**</td>
<td>(1.29)</td>
<td>(15.75)**</td>
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</tr>
<tr>
<td><strong>Difference</strong> ( c )</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>S</td>
<td>-0.011</td>
<td>0.067</td>
<td>0.318</td>
<td>0.090</td>
<td>0.4359</td>
<td>306</td>
<td></td>
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<tr>
<td>(1.86)</td>
<td>(7.83)**</td>
<td>(5.04)**</td>
<td>(7.66)**</td>
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<tr>
<td>F</td>
<td>0.039</td>
<td>0.067</td>
<td>0.100</td>
<td>0.083</td>
<td>0.3654</td>
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<tr>
<td>(2.42)**</td>
<td>(7.10)**</td>
<td>(1.25)</td>
<td>(6.54)**</td>
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</tr>
</tbody>
</table>

(a) For explanation of symbols, see text.

(b) In \( \ln \) \( G_{ij} \), \( H_{ij} \), \( C_{ij} \)
(c) \( (G_{ij}-C_{ij}), (H_{ij}-H_{ij}) \)

International and Intra-Regional Trade
TABLE 4
Explanation of Intercountry Differences in the Pattern of Specialization in Manufactured Goods in the Multilateral Framework: Trade Between Developed and Developing Countries (a)
(WLS and GLS estimates of two-stage model, with t-values in parenthesis)

<table>
<thead>
<tr>
<th>Definition of Intercountry Differences in Capital Endowment</th>
<th>Stock Flow</th>
<th>( \alpha^b )</th>
<th>( \alpha^b )</th>
<th>( \alpha^b )</th>
<th>( \beta^b )</th>
<th>( \gamma^b )</th>
<th>( \beta^b )</th>
<th>( R^2 )</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>ratio (^b)</td>
<td>S</td>
<td>0.109</td>
<td>0.129</td>
<td>-0.018</td>
<td>(3.33)**</td>
<td>(8.07)**</td>
<td>-0.87</td>
<td>0.7577</td>
<td>352</td>
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<td></td>
<td>F</td>
<td>0.099</td>
<td>0.133</td>
<td>0.005</td>
<td>(2.80)**</td>
<td>(7.56)**</td>
<td>0.21</td>
<td>0.7427</td>
<td>352</td>
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<tr>
<td>difference (^c)</td>
<td>S</td>
<td>0.062</td>
<td>0.667</td>
<td>0.034</td>
<td>(1.77)(\Delta)</td>
<td>(8.24)**</td>
<td>(1.78)(\Delta)</td>
<td>0.7643</td>
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</tr>
<tr>
<td></td>
<td>F</td>
<td>0.058</td>
<td>0.678</td>
<td>0.052</td>
<td>(1.55)(\Delta)</td>
<td>(7.74)**</td>
<td>(2.52)**</td>
<td>0.7491</td>
<td>352</td>
</tr>
<tr>
<td>ratio (^b)</td>
<td>S</td>
<td>-0.014</td>
<td>0.339</td>
<td>0.066</td>
<td>(0.70)(\Delta)</td>
<td>(14.30)**</td>
<td>(7.01)**</td>
<td>0.6512</td>
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<tr>
<td></td>
<td>F</td>
<td>0.012</td>
<td>0.249</td>
<td>0.073</td>
<td>(0.50)(\Delta)</td>
<td>(14.28)**</td>
<td>(7.01)**</td>
<td>0.6494</td>
<td>704</td>
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<td>difference (^c)</td>
<td>S</td>
<td>0.001</td>
<td>0.216</td>
<td>0.301</td>
<td>(0.05)(\Delta)</td>
<td>(14.05)**</td>
<td>(6.19)**</td>
<td>0.6449</td>
<td>704</td>
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<td>F</td>
<td>0.027</td>
<td>0.229</td>
<td>0.339</td>
<td>(1.05)(\Delta)</td>
<td>(14.25)**</td>
<td>(5.85)**</td>
<td>0.6441</td>
<td>704</td>
</tr>
</tbody>
</table>

(a) For explanation of symbols, see text.
(b) \( \ln \frac{G_i}{G_j}, \ln \frac{H_i}{H_j} \)
(c) \( (G_iG_j), (H_iH_j) \)
TABLE 5
Explanation of Intercountry Differences in the Pattern of Specialization in Manufactured Goods in the Multilateral Framework: Trade Among Developing Countries (a)
(WLS and OLS estimates of two-stage model, with t-values in parenthesis)

<table>
<thead>
<tr>
<th>Definition of Intercountry Differences in Capital Endowment</th>
<th>Stock Flow</th>
<th>$a^r$</th>
<th>$a^p$</th>
<th>$a^b$</th>
<th>$b^r$</th>
<th>$b^p$</th>
<th>$b^b$</th>
<th>$g^2$</th>
<th>N</th>
</tr>
</thead>
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<tr>
<td><strong>Ratio</strong></td>
<td>S</td>
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<td>0.051</td>
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<td>0.034</td>
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<td>S</td>
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<td>S</td>
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<td>-0.095</td>
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<td>0.0007</td>
</tr>
</tbody>
</table>

(a) For explanation of symbols, see text.
(b) $\ln \frac{C_{ Ik}}{C_{ I}} - \ln \frac{H_{ Ik}}{H_{ I}}$
(c) $(G_{ Ik} - H_{ Ik})$
REFERENCES


