7 An Empirical Analysis of Intra-Industry Trade and Multinational Firms

Elizabeth Wickham and Henry Thompson*

7.1 INTRODUCTION

Trade in goods which are similarly classified in production but are not perfect substitutes in consumption is apparently a growing component of world trade. Reduced tariffs enacted by customs unions have resulted in increased gross trade, while net exports and imports within commodity classifications change very little. Trade theory which assumes constant returns to scale and homogeneous goods generally predicts increased specialisation and inter-industry trade.

When data show simultaneous exports and imports of a single category of goods, there is either categorical aggregation or true intra-industry trade.[1] The latter has been modelled by broadening the factor proportions theory to include two basic aspects of imperfect competition, namely differentiated products and increasing returns to scale. Helpman and Krugman (1985) put together a general equilibrium theory which includes both decreasing costs and demand for horizontally differentiated products, and which breaks new ground in understanding the role of multinational firms.

The present study proceeds from their theoretical propositions concerning changes brought about by multinationals on the influence of key determinants of intra-industry trade. Support is found for their hypothesis that when multinational firms are present, differences in relative factor endowments do not necessarily have the expected negative influence on the share of trade which is intra-industry. Empirical results also bring the assumption of homothetic production into question.

Section 7.2 presents an analysis in the form of some fundamental

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propositions on the basic model with product differentiation, scale economies, and multinational firms. Variables are defined, the data described, and the method of analysis presented in Section 7.3. Section 7.4 contains an examination of the empirical tests of the basic propositions of Section 7.2. Comments on some implications of this study and directions for further research conclude the chapter.

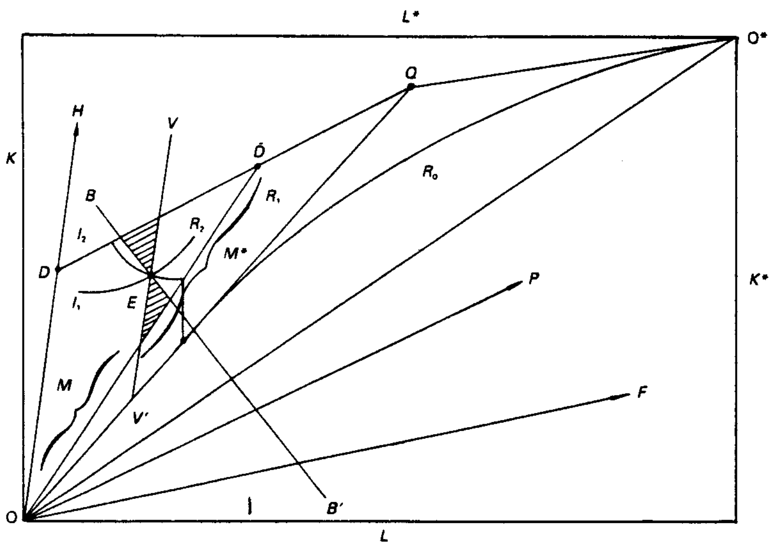
7.2 INTRA-INDUSTRY TRADE MODEL

The foundation for the present approach is an offspring of the well-known Heckscher–Ohlin general equilibrium model of trade. There are two sectors, one producing homogeneous food and the other heterogeneous manufactured goods. There is full employment of two primary productive resources, labour and capital. Production of differentiated manufactured goods is assumed to be relatively capital intensive, utilising headquarter and plant services as intermediate inputs. Free entry and exit in both industries ensures zero profit. Production functions are linearly homogeneous in food, but with increasing returns in manufactures. Monopolistic competition occurs in manufactures, as developed by Chamberlin (1933). Multinational firms are seen to arise when there are differences across countries in relative factor payments. Helpman (1984) and Helpman and Krugman (1985, chs 7, 8, and 12) have developed this model.

Total output of manufactures in the home country can be represented by $X = nx$, where n is the number of firms and x is output per firm. Similarly, in the foreign country, $X^* = n^*x^*$. Trade is assumed to be balanced between the two countries. These manufac-

If two countries were identical in their capital to labour ratios, all trade would be intra-industry. Assume that the home country is capital-rich relative to the foreign country. Then the foreign country exports both food and varieties of manufactures but is a net importer of manufactures, producing a smaller number of varieties than the home country. Both inter-industry and intra-industry trade occur, so intra-industry's share in total trade would be less than one.
tured goods are differentiated, but by assumption can be consistently aggregated. Tastes are assumed to be homothetic and identical in both countries. In each country the same proportions of the homogeneous good and each variety of the differentiated product are consumed. Each country's consumption share is thus determined by relative country size.

Figure 7.1 Share of intra-industry trade



Equal intra-industry trade share lines can be derived. Suppose region R_O is the set of factor endowments in Figure 7.1 where trade equalises factor prices in the absence of multinational firms. Relative size of the home country is represented by s and that of the foreign country by $s^* = 1 - s$. If p is the price of a variety, then the volume of intra-industry trade equals twice the exports of manufactures in the foreign country, $2spX^*$. The share of intra-industry trade in total trade is

$$S = 2spX^*/2s^*pX = sX^*/s^*X$$

It follows that

$$S' = (s/s^*)' + (X^*/X)' \tag{7.1}$$

where primes represent percentage changes, i.e. $S' = dS/S$.

Since X^* decreases relative to X as the capital-rich country becomes more capital abundant, *ceteris paribus*, two propositions follow immediately from equation (7.1):

Proposition 7.1a

If factor price equalisation occurs with only national firms and factor endowment differences between two trading countries increase holding s/s^* constant, then the share of intra-industry trade in total trade will decrease.

Proposition 7.1b

If factor price equalisation occurs with only national firms and relative size of the capital-rich country increases holding X/X^* constant, then the share of intra-industry trade in total trade will increase.

In region R_O isoshare curves emanate from the foreign country origin O^* as in Figure 7.1, and can be convex or concave depending on whether intra-industry's share of total trade is more sensitive to relative country-size changes or to relative endowment changes.[2] The qualitative effect of similarity of country size tested by Loertscher and Wolter (1980) can be summarised as follows:

Proposition 7.1c

If factor price equalisation occurs with only national firms and two trading countries become more similar in size (s/s^* approaches 1) holding X/X^* constant, then the share of intra-industry trade (i) will increase when the capital-rich country is relatively smaller ($s/s^* < 1$); and (ii) will decrease when the labour-rich country is relatively smaller ($s/s^* > 1$).

Multinational firms are introduced by considering the production of manufactures as the sum of two intermediate activities, specialised headquarter services and plant services. Both are assumed to be produced with the primary inputs capital and labour through homogeneous production functions. Headquarter services are assumed to be more capital-intensive than plant services, and can serve in one country while being located in another. Figure 7.1 shows the home country's expansion paths for headquarter services *OH*, for plant services *OP*, and for food *OF*.

When multinationals are present, the capital-rich home country exports headquarter services to the foreign host country, and may be either a net importer or net exporter of manufactured goods. If the home country is extremely capital-abundant, it exports a great deal of headquarter services and is a net importer of manufactured goods as well as food. This region of the factor price equalisation set is called R_2. If the home country is less capital-abundant, it exports headquarter services and is also a net exporter of manufactures. This region, R_1, lies between R_O and R_2 in factor endowment space as pictured in Figure 7.1.

Trade isoshare curves in the presence of multinationals (in regions R_1 and R_2) have different properties. As derived in Helpman and Krugman (1985, ch. 12), when the home country is a net exporter of manufactured goods in R_1, the rate of change in the share of intra-industry trade in total trade is expressed by

$$S' = [pxM^*/(Y + pxM^*)]' \qquad (7.2)$$

where total world food production is represented by Y and the number of varieties of manufactured goods produced in the foreign country by M^*. Since M^* is constant along lines parallel to the linear expansion path of headquarter services, isoshare curves in R_1 are straight lines parallel to this path as in Figure 7.1. Three propositions follow from equation (7.2):

Proposition 7.2a

With multinationals present, if the capital-rich country is a net exporter of manufactured goods and factor endowment differences between the two countries increase holding s/s^* constant, then M^* increases and the share of intra-industry trade in total trade will increase.

Proposition 7.2b

With multinationals present, if the capital-rich country is a net exporter of manufactured goods and its relative size increases holding X/X^* constant, then M^* decreases and the share of intra-industry trade in total trade will decrease.

Proposition 7.2c

With multinationals present, if the capital-rich country is a net exporter of manufactured goods and the countries become more similar in size holding X/X^* constant, then the share of intra-industry trade (i) will decrease as M^* decreases when the capital rich country is relatively smaller ($s/s^* < 1$), and (ii) will increase as M^* increases when the labour-rich country is relatively smaller ($s/s^* > 1$).

Isoshare curves may assume various shapes when the home country is a net importer of manufactured goods in region R_2. In this region the rate of change in the share of total trade which is intra-industry is given by

$$S' = (s^*/s)' + [M/(Y/px + M^*)]' \tag{7.3}$$

where M is the number of varieties produced in the home country.

With $D\tilde{D}Q$ drawn parallel to OP, $OD\tilde{D}$ is identified as region R_2. Moving up from the original endowment point E along iso-income line BB' with factor endowment differences increasing and relative country-size constant, the relative number of varieties produced in the home country (M/M^*) and the share of intra-industry trade both decrease. Moving up from endowment point E along line VV' parallel to OH with relative size of the home country increasing and the relative number of varieties produced at home constant, the share of intra-industry trade must again decrease. Thus the isoshare curve through point E cannot cut through the shaded areas where both s^*/s and M/M^* move in the same direction. Two possible convex isoshare curves are drawn as l_1 and l_2.[3] Although concave curves need not be ruled out, careful examination of Figure 7.1 leads to the following propositions:

Proposition 7.3a

With multinationals present, if the capital-rich country is a net importer of manufactured goods and factor endowment differences between the two countries increase (moving north-westerly from E along BB' holding s/s^* constant), then the share of intra-industry trade in total trade will decrease.

Proposition 7.3b

With multinationals present, if the capital-rich country is a net importer of manufactured goods and the relative size of the capital-rich country increases (moving north-easterly from E parallel to OF holding X/X^* constant), then the share of intra-industry trade in total trade will increase if contour lines have positive slope greater than OF (l_1), and will decrease if contour lines have negative slope (l_2).

Proposition 7.3c

With multinationals present, if the capital-rich country is a net importer of manufactured goods and the countries become more similar in size (moving parallel to *OF* holding X/X^* constant), then the share of intra-industry trade will decrease when (i) the labour-rich country is relatively smaller ($s/s^* > 1$) and the contour lines have positive slope greater than *OF* (l_1), or (ii) the capital-rich country is relatively smaller ($s/s^* < 1$) and the contour lines are negatively sloped (l_2). This share increases when (i) the capital-rich country is relatively smaller ($s/s^* < 1$) and the contour lines have positive slope greater than *OF* (l_1), or (ii) the labour-rich country is relatively smaller ($s/s^* > 1$) and the contour lines are negatively sloped (l_2).

Effects on intra-industry's share in total trade from three additional country variables are also tested. First, size of the endowment box itself makes a difference. Lancaster (1980), Krugman (1979, 1981), and Helpman (1981) all show that as a country grows proportionately in labour and capital, output of the differentiated product increases more than proportionately because both the number of firms (n) and output per firm (x) increase:

Proposition 7.4

As the average size of two countries increases, the share of intra-industry trade in total trade will increase.

An exogenous variable measuring the probability that output of an industry is differentiated rather than homogeneous is also included. Helpman and Krugman (1985, ch. 8) argue that if differentiated products are capital-intensive, their production will be relatively important in economies with relatively high capital to labour endowments. If two trading countries have relatively high endowments of capital, then it is more likely that their trade will be intra-industry:

Proposition 7.5

As the average capital-to-labour ratio for two countries increases, the share of intra-industry trade in total trade will increase.

A new approach to the problem of measuring the degree of product differentiation is introduced in response to suggestions from Tharakan (1983) and others. It is formulated on the Lancaster (1979) premise that consumers' tastes are defined by their 'ideal' variety, a vector located in characteristics space having a dimension less than that of the product space. A special quasi-oligopolistic assumption that rival firms engage in price competition only to remain efficient, together with scale economies at the firm level, leads to a special configuration of industry prices derived and applied in Wickham (1981, 1987). This equilibrium is characterised by a price structure where varieties are 'just relevant commodities' (*JRC*) and are linearly related to one another. If k is the dimension of characteristics space, then k linearly independent variety prices are sufficient to explain all variation in prices. Variable k for an industry in equilibrium contains a great deal of information about consumer technology, and its estimate can be used to test the following proposition:

Proposition 7.6

As the degree of product differentiation within a product group increases, the share of intra-industry trade in total trade will increase.

Three additional industry characteristics, namely the level of multinational activity, the degree of scale economies, and the degree of categorical aggregation, are tested for their effect on intra-industry's share of total trade.

Caves (1981) and others point out that the relationship between the degree of multinational presence and intra-industry's share is ambiguous. The issue turns on how direct foreign investment relates to trade flows within categories. If multinationals invest abroad as the next step from exporting to put production closer to foreign markets, exports from the home country and possibly intra-industry trade will diminish. On the other hand, trade in intermediate goods or intra-firm trade in general might increase with foreign investment, thus augmenting intra-industry trade:

Proposition 7.7

To the extent that foreign direct investment is a substitute (complement) for trade in differentiated products, more investment means a negative (positive) effect on intra-industry trade's share in total trade.

Scale economies prevent countries from producing a continuum of products domestically. With increasing scale economies at the firm level, each variety is more efficiently produced by a single firm. All red cars, for example, will then be produced in one country, and all blue cars in another. Similar tastes across countries and a 'taste for variety' then ensure two-way trade. Although a minimal level of scale economies in part explains intra-industry trade, increasing returns beyond this level have no additional effect. The number of producers $(n + n^*)$ will then decrease as each firm's output (x) increases, with total industry output unchanged until the number of firms shrinks to one:

Proposition 7.8

Economies of scale which are external to the firm beyond a minimal level will have no effect on the share of intra-industry trade.

Contrary to assumption, it may not be possible consistently to aggregate goods within a category. There will then be differences in factor requirements within each product group leading to the appearance of intra-industry trade. An additional variable to measure categorical aggregation is tested:

Proposition 7.9

If factor input ratios are not constant across differentiated goods, then more disaggregation will result in a lower share of intra-industry trade in total trade.

7.3 EMPIRICAL PROCEDURE

Bilateral intra-industry trade flows over twelve years across a broad range of eighteen industries for a total of 351 country pairs are examined. The independent variables include five country and four industry characteristics whose expected effects are summarised in Propositions 7.1–7.9. These variables are defined and their measurements discussed.

For endowments in the factor price equalisation set, if w_L and w_k are labour and capital payments and K/L is the relative factor endowment, then income per capita can be written $GNP/L = w_L + w_k(K/L)$. Thus relative factor endowments are positively related to income per capita. Absolute value of the difference in income per capita between country pairs is divided by the mean to obtain an estimate of the first country determinant, relative factor endowment difference (*PCID*).[4] The expected sign of *PCID* is described in Propositions 7.1a, 7.2a and 7.3a for regions R_0, R_1, and R_2 respectively. To the extent that tastes differ, this variable also captures the Linder (1961) effect that intra-industry trade will be highest between countries with similar per capita incomes.

Relative *GNP* of the capital-rich country is used as relative country size (*SIZR*). Propositions 7.1b, 7.2b and 7.3b describe the expected effects of this variable.

Difference in country size (*SIZD*) is measured as the product ss^* of country shares, which works out to the product of *GNP*s divided by the square of the sum of *GNP*s. As country pairs become more similar in size, *SIZD* increases to 0.25. Propositions 7.1c, 7.2c and 7.3c pertain to this variable.

Average size of the country pair (*SIZA*) is measured by the mean of *GNP*s. Its effect is expected to be positive, as stated in Proposition 7.4.

The mean of income per capita (*PCIA*) is the proxy used for average relative factor endowments. Proposition 7.5 predicts a positive relationship for this variable.[5]

The proxy for product differentiation (*PRDIF*) or the rank of Lancaster's consumer technology matrix is measured by the estimated number of principal factors with eigenvalues greater than or equal to 0.5. We use the method of principal factoring with the squared multiple correlation between a variable and the rest of the variables as communalities. See Wickham (1987) for a comparison of the results from several alternative factor analysis techniques and the widely used Hufbauer (1970) index of price dispersion.[6] A positive relation is proposed in Proposition 7.6.

Two measures of the level of multinational presence are explored. One proxy (MN_1) is available by industry and year, and is tested as an additional industry characteristic. The other (MN_2) is available by industry and country pair, and serves as a control variable for regions of the factor price equalisation set. These applications are selected because of the nature of the data. Variable MN_1 is obtained from the appendix of Caves (1981).[7] This variable measures activities of multinational corporations considered to be alternatives to intra-industry trade and is expected to have the negative relationship in Proposition 7.7. The variable MN_2 is based on a profile study of US corporations compiled in 1981 by the Department of Commerce. It is considerably more aggregated than 3-digit SITC codes, but these are the only US data available by country.[8]

To test the hypothesis stated in Proposition 7.8, the Hufbauer (1970) measure of scale economies *SCH* is utilised. This data is obtained for each employment size class and not at the individual variety level, so *SCH* is expected to be insignificant.[9]

Finally, the usual proxy for the degree of categorical aggregation is calculated. Variable *AGG* is defined as the number of 7-digit codes within each 3-digit old Schedule B code.[10] Its expected sign is positive.

Originally derived by Grubel and Lloyd (1975), the dependent variable measures the difference between gross and net trade as a percentage of total trade. For every industry i, country pair jk, and year t in which trade occurs, the index is calculated according to

$$S_{i,jk,t} = \left\{1 - \frac{|X_{i,jk,t} - M_{i,jk,t}|}{(X_{i,jk,t} + M_{i,jk,t})}\right\} 100$$

It ranges from 100 with all intra-industry trade to 0 with all inter-industry trade. No attempt is made to adjust for the Aquino bias.

Data on export values from 1970 to 1981 comes from UN Statistical Office records, collected at the 3-digit SITC level using the old Schedule B classification.[11] As mentioned, the study involves eighteen industries (both manufacturing and other)[12] and twenty-seven countries (nine industrialised, six newly industrialised, and twelve developing).[13] Our master file contains almost 40 000 observations.[14]

Table 7.1 summarises the variables, their proxy character, and expected signs in each region of the factor price equalisation set. Where appropriate, the size of s/s^* and the slope of the isoshare trade curves are listed.

7.4 EMPIRICAL RESULTS

The pooled cross-section and time-series nature of the data leads to a check for autocorrelation on preliminary OLS results. In some of the estimations with fewer observations, the null hypothesis of autocorrelation cannot be rejected using a Durbin–Watson test. In some others the results are indeterminate. Generalised least squares, with various lag operators and the back-step procedure to eliminate insignificant autoregressive parameters, is thus utilised. GLS results differ only slightly from those of OLS. A Madalla test described by Rossini (1983, footnote 17) indicates stability of the coefficients over the twelve years. Thus, only OLS results are reported.

Table 7.1 Expected signs

	Factor endowment difference (PCID)	Relative size of capital – rich country (SIZR)	Country size difference (SIZD)	Average size of country pair (SIZA)	Average per capita income of country pair (PCIA)	Degree of product differentiation (PRDIF)	Level of multinational presence (MN_1)	Scale economies (SCH)	Categorical aggregation (AGG)
R_0 $s/s^* < 1$	−	+	+	+	+	+	−	0	+
$s/s^* > 1$	−	+	−	+	+	+	−	0	+
R_1 $s/s^* < 1$	+	−	−	+	+	+	−	0	+
$s/s^* > 1$	+	−	+	+	+	+	−	0	+
R_2 l_1 $s/s^* < 1$	−	+	+	+	+	+	−	0	+
R_2 l_1 $s/s^* < 1$	−	+	+	+	+	+	−	0	+
R_2 l_2 $s/s^* < 1$	−	−	−	+	+	+	−	0	+
R_2 l_2 $s/s^* > 1$	−	−	+	+	+	+	−	0	+

Tables 7A.1 to 7A.4 in the Appendix summarise the series of regressions. In Table 7A.1, the entire data set is utilised, drawing from observations in each of the three regions of factor price equalisation. Table 7A.2 looks at region R_0 with only national firms. Table 7A.3 examines region R_1 where some producers of the differentiated product are multinational firms and the home country is a net exporter of manufactures. Table 7A.4 then looks at region R_2 where multinational firms are present and the home country is a net importer of the differentiated product. When necessary to introduce certain variables, the data set is restricted. This is pointed out by the number of observations *n* reported in the last column and the corresponding footnotes.

All tables report the results of five regressions. Regression *a* includes the five country and four industry determinants which have been discussed earlier. Regressions *b* and *c* are reported to indicate the combined explanatory power of the single most important industry determinant along with all country variables. Comparison of regression *b* and *c* separates out the role played by the product differentiation proxy. Regression *d* drops the country variable which accounts for the least sum of squares, while regression *e* includes the three most powerful determinants.

Although adjusted R^2s are not outstanding in Table 7A.1, only a few variables are being used to explain all the variation in up to 39 759 observations of the pooled data. All five country variables are consistently significant. The negative signs of *PCID* and *SIZR* and the positive sign of *SIZD* indicate that on average:

(i) observations are located in R_2;
(ii) $s/s^* > 1$;
(iii) isoshare curves have negative slope.

This is the last case listed in Table 7.1. Both *SIZA* and *PCIA* have expected positive signs, except in the restricted data set A1a. This exception can probably be explained by multicollinearity. In the remaining tables, which are also based on smaller samples, this same multicollinearity occurs.

When the effect of product differentiation *PRDIF* is included, comparing regressions A1b and A1c, the number of observations drops to 20 520 and the adjusted R^2 increases. Variable *PRDIF* is correctly signed and significant. Regression A1a examines the joint influence of country variables, product differentiation, and the three other industry determinants. Because the data allows calculation of

MN_1 for US bilateral trade only, the number of observations drops to 3023. Variables MN_1 and *AGG* are not significant. The measure of scale economies *SCH* is also insignificant, confirming that *SCH* is a measure of economies at the industry and not variety level. Including the additional industry determinants boosts R^2 by 61 per cent.

Remaining tables are derived from further subsets of the 3023 observations in regression A1a. In Table 7A.2, variable MN_2 is used to isolate observations in region R_0 where there is no multinational presence. Observations with disclosure problems and country pairs not recorded in the Commerce Department study are excluded. The sample size reduces to 72 observations, which result in systems of less than full rank when variable *PRDIF* is included. Regressions A2d and A2e confirm that *SIZR* has the expected positive sign and is significant. Moreover, *PCID* is negatively signed as expected. Variable *SIZD* is not significant in two regressions, and is significantly negative at the 5 per cent level in the third. This would indicate that on average $s/s^* > 1$ in this subsample.

The five regressions in Table 7A.3 include 1611 observations in region R_1 for all non-zero values of MN_2 where the capital-rich country is a net exporter of the differentiated product. The expected negative sign of *SIZR* is confirmed in this region. A significantly positive value for *SIZD* suggests that the country with a higher income per capita tends to have the higher *GNP* for the entire region. Variables MN_1 and *SCH* are not significant. Variable *AGG* is significant but with a negative effect, because of multicollinearity with PRDIF. The most striking result is that examination of this region uncovers an effect opposite to that expected for *PCID*, since all *t* values are significantly negative. The qualitative relationship between *PCID* and intra-industry's share in total trade anticipated by Helpman and Krugman is not discovered. This suggests a parcelling of the region into segments for further analysis.

Region R_1 is sliced into segments according to income differences. This amounts to moving systematically in a north-westerly direction along BB', separating region R_1 by making cuts parallel to 00^* in Figure 7.1. Four of these subregions are presented in Tables 7A.4 to 7A.7. In regressions A4 with per capita income difference (*DIF*) ranging from \$2000 to \$3000, there are 120 observations. The sign of *PCID* is positive and statistically significant at acceptable levels in four of the five regressions. The sign of *SIZR* is again negative, similar to results reported for the entire region R_1. Large positive *t* values for *PRDIF* still occur for every regression, the adjusted R^2

rising dramatically (from 0.086 to 0.216) by its inclusion. Coefficients of *PRDIF* suggest that the index of intra-industry trade will increase by more than eight points for every characteristic added to an industry. The remaining independent variables lose much of their significance.

A second slice of R_1 moving up from 00* in Figure 7.1 is performed in regressions A5 by examining the 133 observations where per capita income difference is between \$3000 and \$4000. In regressions A5d and A5e, the variable *PCID* is significantly negative. This would indicate that isoshare curves in this subregion of R_1 bend to the north-west with negative slope and are flatter than the relative income line BB'. The assumption of homothetic production is contradicted. Variable MN_1 assumes an unexpected positive sign. The adjusted R^2s are quite high in this slice.

Parcelling R_1 into a third slice of 430 observations with per capita income difference between \$4000 and \$6000 suggests that isoshare curves continue to bend backward. In regressions A6d and A6e, variable *PCID* is statistically significant and negative, while *SIZR* is significantly negative as expected.[15] Variable *SIZD* is significant and positive in the regressions where it is included, suggesting again that on average $s/s^* > 1$ in this subsample.

As reported in the five regressions of Table 7A.7, a second bend in the isoshare curve back to the north-east is indicated. Per capita income differences between \$6000 and \$8000 are included in this sample, resulting in 296 observations. Evidence from regression A7d in particular suggests that *PCID* again has a positive effect.

Taken together, these twenty regressions contain valuable information pertaining to the production structure of differentiated products. Since isoshare curves in region R_1 are parallel to the expansion path for headquarter services, there is strong evidence that path *OH* goes north-east, bends north-west, and then bows north-east again. This empirical evidence does not support the simplifying assumption of homothetic production for the differentiated products.

Finally, in order to isolate region R_2, non-zero values of MN_2 indicating multinational presence are examined where the home country is a net importer of goods in a particular category. These results in Table 7A.8 continue to confirm hypotheses of the model. Each regression displays a significant negative effect for *PCID*. In addition, *SIZR* is significantly negative in regression A8a, indicating that isoshare curves have a negative slope (ℓ_2) in this region. The negative sign of *SIZD* suggests that $s/s^* < 1$ for this subsample.

Variables *AGG* and *PRDIF* again exhibit multicollinearity as shown by their opposite signs in regression A8a.

7.5 CONCLUSION

A systematic empirical examination of the influence which multinational firms have on the effects of determinants of intra-industry trade confirms major propositions of the Helpman–Krugman model of trade in differentiated products. Varieties are assumed to be produced by firms engaging in intermediate activities with different factor intensities. Horn (1983, p. 86) anticipates non-homotheticity in these models. Our results confirm his suspicions.

Without homotheticity, a distinction between average and marginal factor intensities is suggested, relative factor intensities depend upon the output level, and the usual stipulation of no-factor-intensity-reversals becomes more complicated. Thus, to ensure factor price equalisation and identical output per firm, there is a need to re-examine necessary and sufficient conditions for univalence of the mapping between factor payments and output per firm on the one hand versus commodity prices and the number of firms on the other.

Horn develops a general equilibrium economy with non-homothetic production of differentiated products and unitary elasticity of demand between sectors. Although output per firm is no longer independent of factor prices, all important properties of the homothetic model are preserved when there is a local bias in favour of the factor used intensively. Empirical results of the present study strongly suggest that the modelling of intra-industry trade with non-homothetic production should include this bias.

APPENDIX 7.1. Detailed results of the regression analysis

Table 7A.1 Regions R_0, R_1, and R_2 combined; estimated coefficients (t-values)

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A1a	32.0	−19.8	−0.009	120	0.00003	−0.01	3.22	−25.0	−9.70	−0.030			
	(5.02)	(−5.80)	(−4.60)	(5.60)	(2.60)	(−2.70)	(5.80)	(−0.46)	(−1.50)	(−0.67)	0.240	71.2	3 023[2,3]
A1b	0.123	−6.50	−0.02	22.3	0.00002	0.002	1.62						
	(0.131)	(−20.0)	(−11.5)	(8.80)	(22.1)	(13.8)	(11.2)				0.149	389	20 520[2]
A1c	9.95	−6.80	−0.02	21.3	0.00002	0.001							
	(25.6)	(−34.5)	(−15.8)	(13.8)	(33.8)	(19.9)					0.123	1119	39 759[1]
A1d	3.21	−7.04	−0.02		0.00002	0.002	1.64						
	(3.72)	(−22.1)	(−13.4)		(20.2)	(15.1)	(11.3)				0.144	449	20 520[2]
A1e	15.3	−8.75	−0.003				1.23						
	(19.7)	(−26.9)	(−2.00)				(8.20)				0.060	284	20 520[2]
Expected signs		?	?	?	+	+	+	−	0	+			

[1] *All 18 SITCs*
[2] Subset including 10 *SITCs* for which *PRDIF* can be calculated. See note 6 in main text.
[3] Subset including all US bilateral trade.

Table 7A.2 Region R_0

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A2a*	156	−82.5	0.18	−170	0.0002	−0.04		−155					
	(2.23)	(−2.36)	(1.43)	(−0.88)	(1.53)	(−1.61)	.	(−0.66)	.	.	0.345	5.1	72[2,4]
A2b*	147	−80.2	0.17	−168	0.0002	−0.04							
	(2.20)	(−2.32)	(1.41)	(−0.87)	(1.48)	(−1.55)	.				0.354	6.1	72[2,4]
A2c*	122	−64.4	0.11	−229	0.0001	−0.02							
	(3.20)	(−3.32)	(1.07)	(−1.90)	(1.84)	(−1.80)					0.330	8.0	72[2,4]
A2d*	95.6	−55.2	0.24		0.0001	−0.02							
	(2.80)	(−2.86)	(2.50)		(1.24)	(−1.34)					0.357	7.5	72[2,4]
A2e*	53.1	−30.2	0.15										
	(6.30)	(−5.09)	(2.45)				.				0.359	14.2	72[2,4]
Expected signs		−	+	?	+	+	+	−	0	+			

* Not full rank
[2] As note 2 on Table 7A.1.
[4] Subset including US bilateral trade for which MN_2 can be calculated. See note 8 in main text.

Table 7A.3 Region R_1

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A3a	32.0	−15.1	−0.09	91.2	0.00003	−0.01	4.77	24.3	−1.15	−0.16			
	(3.57)	(−3.21)	(−4.93)	(2.42)	(4.82)	(−2.15)	(5.80)	(0.264)	(−0.12)	(−2.09)	0.190	28.9	1611[2,4]
A3b	33.5	−15.1	−0.09	89.3	0.00003	−0.01	3.40						
	(3.76)	(−3.20)	(−4.83)	(2.36)	(1.78)	(−2.10)	(6.17)				0.187	42.1	1611[2,4]
A3c	28.9	−3.12	−0.07	115	−0.00001	0.002							
	(5.26)	(−1.04)	(−4.90)	(6.02)	(−1.91)	(1.24)					0.169	66.5	1611[2,4]
A3d	47.1	−22.0	−0.11		0.0001	−0.01	3.37						
	(6.93)	(−6.02)	(−8.11)		(4.23)	(−4.54)	(6.11)				0.184	49.2	1611[2,4]
A3e	25.9	−6.66	−0.13				3.30						
	(9.06)	(−4.81)	(−9.62)				(5.92)				0.170	73.9	1611[2,4]
Expected signs		+	−	?	+	+	+	−	0	+			

[2] As Note 2 on Table 7A.1.
[4] As Note 4 on Table 7A.2.

Table 7A.4 Region R_1 with $2000 < DIF < 3000$

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A4a	–160	114	–0.16	241	–0.0003	0.06	12.6	170	27.2	–0.47	0.217	4.2	120[2,4]
	(–2.02)	(2.03)	(–1.47)	(1.03)	(–1.37)	(1.60)	(4.14)	(0.57)	(0.79)	(–1.79)			
A4b	–152	116	–0.18	221	–0.0003	0.06	8.44				0.216	5.8	120[2,4]
	(–1.91)	(2.07)	(–1.66)	(0.94)	(–1.36)	(1.59)	(4.36)						
A4c	–112	112	–0.18	231	–0.0003	0.06					0.086	3.2	120[2,4]
	(–1.37)	(1.93)	(–1.98)	(1.26)	(–1.53)	(1.63)							
A4d	–112	98.8	–0.25		–0.0001	0.03	8.42				0.217	6.8	120[2,4]
	(–1.67)	(1.87)	(–3.19)		(–1.21)	(1.44)	(4.35)						
A4e	–2.13	19.2	–0.18				8.36				0.209	10.3	120[2,4]
	(–0.14)	(0.83)	(–3.33)				(4.31)						
Expected signs		+	–	?	+	+	+	–	0	+			

[2] As Note 2, Table 7A.1.
[4] As Note 4, Table 7A.2.

Table 7A.5 Region R_1 with $3000 < DIF < 4000$

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A5a	5.31	-33.6	0.0004	192	0.0002	-0.02	4.07	513	-46.2	0.32	0.503	13.5	133[2,4]
	(0.05)	(-0.50)	(0.01)	(0.68)	(0.60)	(-0.48)	(1.80)	(2.02)	(-1.67)	(1.50)			
A5b	17.3	-38.6	-0.03	155	0.0002	-0.02	7.20				0.464	17.0	133[2,4]
	(0.17)	(-1.56)	(-0.53)	(0.52)	(0.64)	(-0.52)	(4.92)						
A5c	128	-86.0	-0.06	30	0.0003	-0.04					0.352	15.3	133[2,4]
	(1.90)	(-1.61)	(-1.02)	(0.12)	(1.07)	(-1.17)							
A5d	65.6	-72.3	-0.05		0.0003	-0.05	7.15				0.467	20.5	133[2,4]
	(1.51)	(-2.73)	(-1.16)		(3.71)	(-3.58)	(4.93)						
A5e	32.2	-23.0	-0.18				7.36				0.408	26.5	133[2,4]
	(2.96)	(-2.16)	(-5.79)				(4.83)						
Expected signs		+	−	?	+	+	+	−	0	+			

[2] As Note 2, Table 7A.1.
[4] As Note 4, Table 7A.2.

Table 7A.6 Region R_1 with $4000 < DIF < 6000$

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A6a	28.7	−16.0	−0.02	360	0.00002	−0.01	2.62	−381	7.92	0.12	0.203	11.9	430[2,4]
	(0.93)	(−1.02)	(−0.50)	(3.67)	(0.30)	(−0.38)	(2.12)	(−2.67)	(0.52)	(0.99)			
A6b	26.0	−15.9	−0.02	356	0.00002	−0.004	3.28				0.194	16.5	430[2,4]
	(0.84)	(−1.00)	(−0.57)	(3.61)	(0.21)	(−0.32)	(3.90)						
A6c	46.4	−16.9	−0.03	303	0.00001	−0.004					0.208	23.6	430[2,4]
	(1.93)	(−1.21)	(−0.88)	(3.41)	(0.12)	(−0.30)							
A6d	71.3	−38.8	−0.09		0.0001	−0.03	3.19				0.168	16.6	430[2,4]
	(2.49)	(−2.63)	(−4.06)		(2.02)	(−1.99)	(3.77)						
A6e	36.9	−14.4	−0.12				3.22				0.164	26.2	430[2,4]
	(5.75)	(−4.14)	(−6.57)				(3.81)						
Expected signs		+	−	?	+	+	+	−	0	+			

[2] As Note 2, Table 7A.1.
[4] As Note 4, Table 7A.2.

Table 7A.7 Region R_1 with $6000 < DIF < 8000$

	CONST	*PCID*	*SIZR*	*SIZD*	*SIZA*	*PCIA*	*PRDIF*	MN_1	*SCH*	*AGG*	*ADJ* R^2	*F STAT*	*n*
A7a	−261	144	−0.26	253	−0.001	0.15	3.46	−114	13.2	−0.13	0.104	3.8	296[2,4]
	(−1.34)	(1.52)	(−3.91)	(0.68)	(−1.74)	(1.73)	(2.05)	(−0.60)	(0.66)	(−0.88)			
A7b	−250	140	−0.26	230	−0.001	0.15	2.23				0.106	5.3	296[2,4]
	(−1.28)	(1.48)	(−3.97)	(0.62)	(−1.70)	(1.68)	(2.01)						
A7c	5.13	9.46	−0.14	−34.2	−0.00002	0.01					0.039	3.4	296[2,4]
	(0.12)	(0.42)	(−2.62)	(−0.22)	(−0.320)	(0.48)							
A7d	−139	86.4	−0.27		−0.001	0.10	2.23				0.109	6.3	296[2,4]
	(−1.81)	(2.22)	(−4.45)		(−2.56)	(2.56)	(2.01)						
A7e	31.1	−6.86	−0.14				2.03				0.089	8.1	296[2,4]
	(1.61)	(−0.64)	(−4.48)				(1.82)						
Expected signs		+	−	?	+	+	+	−	0	+			

[2] As Note 2, Table 7A.1.
[4] As Note 4, Table 7A.2.

Table 7A.8 Region R_2

	CONST	PCID	SIZR	SIZD	SIZA	PCIA	PRDIF	MN_1	SCH	AGG	ADJ R^2	F STAT	n
A8a	82.2	–44.3	–0.08	–151	0.0001	–0.02	–1.75	21.0	–38.1	0.84	0.233	14.4	595[2,4]
	(4.84)	(–4.98)	(–2.49)	(–2.39)	(3.45)	(–3.27)	(–1.10)	(0.15)	(–2.55)	(4.95)			
A8b	65.2	–40.4	–0.05	–105	0.0001	–0.01	3.00				0.179	15.4	595[2,4]
	(3.80)	(–4.50)	(–1.61)	(–1.63)	(2.96)	(–2.66)	(2.34)						
A8c	64.3	–28.9	–0.03	–24.0	0.0001	–0.01					0.124	17.8	595[2,4]
	(6.00)	(–4.94)	(–0.92)	(–0.50)	(3.31)	(–3.07)							
A8d	45.5	–29.1	–0.02		0.0001	–0.01	2.97				0.175	17.9	595[2,4]
	(3.72)	(–5.11)	(–0.71)		(2.66)	(–2.17)	(2.31)						
A8e	40.7	–18.8	–0.04				2.99				0.164	27.0	595[2,4]
	(6.36)	(–7.20)	(–1.68)				(2.32)						
Expected signs		+	?	?	+	+	+	–	0	+			

[2] As Note 2, Table 7A.1.
[4] As Note 4, Table 7A.2.

would usually be better to keep the inefficient producer in the market as well. The basic reason is that market deviations from Pareto optimum are greater under monopoly then duopoly.

26. See relations (6.2.2) – (6.2.5) in Appendix 6.2.
27. In the multi-country world much could be said for using a weighted exchange rate in the estimated equations (leaving aside the problem of appropriate weights). We decided, however, to use bilateral nominal rates against the US dollar (and no exchange rate variable in the US equations) for two basic reasons. First, the value of the endogenous variables are expressed in terms of US dollars. Second, most of the shipping rates are quoted in US dollars. Nevertheless, an attempt was made to re-estimate the model with effective exchange rates. We found this variable statistically insignificant for the USA, and generally to worsen the results in the case of all other countries except Canada.
28. However, even a casual look at wage series for most of the developed countries during the period 1973–83 reveals a large degree of collinearity. It was therefore decided to enter only the wage rate of the respective exporting country.
29. For details see section 6.3.
30. One should also keep in mind that dock-workers (as well as truck-drivers) are highly unionised, and their wages may be much higher than for the rest of the industry.
31. We have re-estimated the equation for Canada using the effective exchange rate (e_E) instead. The following results were obtained:

$$\log VTX_t = \underset{(4.23)}{6.388^{**}} + \underset{(4.70)}{0.38^{**}} \log X_t + \underset{(10.73)}{0.45^{**}} \log P_{p,t}$$
$$- \underset{(-4.77)}{0.59^{**}} \log w_t - \underset{(-3.97)}{0.84^{**}} \log e_{Et}$$

$$R^2 = 0.945 \qquad DW = 1.36 \qquad SEE = 0.07$$

32. The justification for this decision is straightforward. The recorded statistics of the value of imports of transportation services are very strongly influenced by the shipping rates (and port charges, etc.) posted by exporting countries which, in turn, are directly affected by the cost of labour in those countries. Of course, the cost of labour in an importing country (country i) is relevant because at the margin there is substitution between alternative suppliers of transportation services. But if a transaction actually did take place, as recorded by the balance-of-payments statistics, it means that labour costs in the exporting country were not found excessively high. And for this reason we selected a composite wage rate in major exporting countries as a relevant determinant of the transportation cost.

7 An empirical analysis of intra-industry trade and multinational firms

1. Gray (1979) combines these two aspects.
2. Helpman and Krugman (1985, p. 177) indicate that isoshare lines are

concave to the diagonal as drawn in R_0. But, following their algebraic treatment, sufficient conditions for convexity to the diagonal are (i) $s^*(2)/s(2) < s^*(1)/s(1)$ (their equation 8.A8), and (ii) $X^*(1)/X(1) < X^*(2)/X(2)$, where (1) and (2) refer to different endowments. This last inequality cannot hold since E_2 lies above O^*Z^* in their Figure 8A.1 when the first inequality is satisfied. The question of convexity seems open. Isoshare curves are convex and steeper than QO^* when (i) dominates (ii), or $s(i)/s^*(i)$ falls faster than $X^*(i)/X(i)$ increases. This occurs when the dependent variable S is more sensitive to relative country size changes than per capita income changes.

3. Helpman and Krugman (1985, Figure 12.7) suggest that isoshare curves inside $OD\tilde{D}$ must be positively sloped as is ℓ_1.
4. Since a \$500 difference in per capita income, for example, may have more effect on the share of intra-industry trade for two countries with relatively low per-capita income, the difference is weighted by the mean. The simple absolute difference is also used in the empirical tests with slightly weaker results.
5. Estimates in real dollars of GNP at market prices and income per capita for each of the selected countries from 1973 to 1983 are provided by the *World Bank Atlas*. For example, 1970 data is extracted from the 1973 *World Bank Atlas* where the most updated estimates for that year are recorded. Because 1984 estimates were not available when the study was undertaken, 1981 statistics were taken from the 1983 edition. *GNP* in national currency is converted to dollars using average prices and exchange rates for a three-year period around the year of observation.
6. Monthly export values of 7-digit SITC levels are obtained from the US Bureau of Census FT–410 for the years of 1970 to 1977. For each month, total export value (in dollars) for all countries is divided by quantity (when available), and repeated for all varieties within a given 3-digit code. The source is *US Foreign Trade, Exports Commodity by Country*, US Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census. Unit export values are chosen because import values could be ridden with price distortions arising from protectionism. After 1977, the old Schedule B classifications were changed to two alternative classifications, the new Schedule B and Schedule E. It thus becomes nearly impossible to obtain a one-to-one correspondence between 7-digit codes recorded before and after January, 1978. Since factor analysis requires a minimum of five observations per variety, enormous numbers of monthly data are needed to estimate adequately the number of basis vectors for some industries. In particular, for industries with more than thirty varieties, the number of monthly observations recorded under the old Schedule B system is not sufficient to estimate variable k. There are eight of the eighteen industries for which no estimate of product differentiation can be obtained using pre-1978 data. They are 053, 641, 651, 678, 714, 717, 732 and 894 (see note 12). With help from the Bureau of the Census, a tape of monthly unit values for the eighteen industries by 7-digit Schedule E code from January 1978 to December 1985 has made it possible to correct for this deficiency in Wickham (1987).
7. Using the *IRS Source Book, Statistics of Income, Corporation Income*

Tax Returns, 1970–1981, a proxy for the extent of foreign investment activity of the corresponding US industry (FDI1 in Caves, 1981) is calculated by summing dividends received from foreign affiliates and foreign tax credits and dividing by total business receipts. Each of the eighteen 3-digit SITC codes is matched with a 4-digit minor industry code and then verified with the IRS. (With the SITC code first and minor industry code second, the following concordance is used: 053–2030, 061–2060, 112–2088, 533–2850, 541–2830, 554–2840, 571–2898, 611–3198, 641–2625, 651–2228, 664–3225, 678–3370, 682–1070, 714–3570, 717–3550, 724–3665, 732–3710, and 894–3998.) Since minor industry codes are slightly more aggregated, it is assumed that measures of minor industry business activity adequately represent activity levels in our corresponding product groups. MN1 relates to the activity of US corporations and is not available by host (foreign) country, so it is applied only to US bilateral trade. This measure may incorrectly state the extent of foreign operations for several reasons. For example, data from branches of US companies are not included, and dividends from foreign affiliates include only taxable income, not deferred income. Nevertheless, it proves useful here and in Caves (1981).

8. MN_2 data is drawn from a study entitled *US Direct Investment Abroad, 1977*. Total assets of affiliates (majority owned non-bank affiliates of non-bank US parent firms) in various countries are divided by total US corporation assets for the major industry code. The *IRS Source Book, 1977* provides information on total industry assets. Data pertaining to Kenya, Jordan, Cameroon, Pakistan, Costa Rica, Algeria, and Ghana are not available. Because disclosure problems prevent some MN_2 data from being published at this disaggregated level, it is assumed that asset proportions for product groups are adequately represented by those published for the major industry groups. The year 1977 is taken to be typical.
9. With data from the *Census of Manufactures: 1963*, Hufbauer calculates the logarithmic slope coefficient across size classes in the regression of value added per person relative to the industry average on plant size (number of employees). The regressions are conducted for 4-digit SIC industry codes (reclassified to 3-digit SITC codes).
10. The Department of Commerce does not record net quantity for certain varieties which are heterogeneous in nature. These varieties are included in *AGG*, but their unit values cannot be part of the correlation matrices upon which our estimates of *PRDIF* are based.
11. We obtained a tape from UN Department of Economics and Social Affairs, Statistics Office, Statistical Papers, *Commodity Trade Statistics*, Series D.
12. Industries include some with very high levels of two-way trade, such as preserved and prepared fruit (053), yarn (651), glass (664), and toys and games (894), as well as some with very low levels, such as sugar (061), soap (554), paper and paper board (641), and road vehicles, motor (732). Completing our list of product groups are alcoholic beverages (112), paints (533), medical products (541), explosives (571), leather (611), iron and steel pipes (678), copper (682), office machines (714), textile and

leather machinery (717), and telecommunications apparatus (724).

13. The industrialised countries are the USA, Japan, Norway, Canada, United Kingdom, Belgium–Luxemburg, Italy, Australia, and Ireland; newly industrialised ones are Korea, Israel, Greece, Mexico, India, and Brazil; and the developing countries are Chile, Malaysia, Columbia, Ghana, Jordan, Algeria, Cameroon, Costa Rica, Pakistan, Kenya, Philippines, and Thailand.
14. Some studies explore differences in intra-industry's share of total trade by averaging across industrialised countries or by examining US trade with the rest of the world, e.g. Hesse (1974), Pagoulatos and Sorensen (1975), Finger and De Rosa (1979), Caves (1981), Gavelin and Lundberg (1983), and Greenaway (1983). Although Loertscher and Wolter (1980) formulate a cross-country, cross-industry analysis, their study is limited to bilateral trade among OECD countries. Others, including Schumacher (1983), Havrylyshyn and Civan (1983), Tharakan (1984), and Balassa (1987), have recently dealt with intra-industry trade in relation to developing countries. Havrylyshyn and Civan aggregate over non-fuel manufactured goods for a mix of countries from industrialised to developing. However, their study does not measure differences between country pairs, an important ingredient of recent theoretical developments.
15. The assumption of similarity in demand may be brought into question as well. If tastes differ across countries and PCID picks up these differences in addition to variances in relative factor endowments, then the negative relationship reported in regressions 7.A5 and 7.A6 may be at least partially explained by an overriding Linder effect. Theoretical aspects of intra-industry trade induced by taste has received recent attention by Dinopoulos (1985) and others.

8 Effective protection analysis and optimal trade policy with intra-industry specialisation and imperfect competition

1. Corden (1971) for instance considers the implications of relaxing the homogeneity and small country assumptions, and Itagaki (1983) investigates the implications of multinational production for effective protection analysis.
2. For a review of the literature on commercial policy and intra-industry trade based on a nominal protection approach, see for example, Greenaway and Milner (1986), Milner (1986), Greenaway (1985) and Venables (1985a).
3. The authors themselves have undertaken some effort in this direction; see Greenaway and Milner (1987a).
4. It is implicitly assumed that intra-industry trade is a 'real' phenomenon which can be measured. This in itself is controversial (see Greenaway and Milner, 1983). For present purposes we abstract entirely from measurement problems.
5. See, for example, Corden (1971) and Greenaway (1983).
6. This might be viewed as a two-stage process completed by the same firm

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