RESOURCE CONVERGENCE AND INTRA-INDUSTRY TRADE

Philip Lowe

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Economic Research Department

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ABSTRACT

Models of international trade based on desire for variety, increasing returns and monopolistic competition predict that the more similar are nations' resource endowments the more important should be intra-industry trade. This prediction is tested using resource data for 22 OECD nations over the period 1965 to 1985. The results provide strong support for the theory. In the time domain they suggest that resource convergence has been responsible for the growth in the importance of intra-industry trade and in cross sections they suggest that the more similar are two countries' resource endowments the more extensive is bilateral intra-industry trade.

TABLE OF CONTENTS

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1. INTRODUCTION

The development of theoretical models explaining two-way trade in similar commodities has resulted in *economies of scale* and *desire for variety* being elevated to a similar stature as factor endowments and intensities as determinants of trade patterns. While considerable effort has been focussed on testing the predictions of the factor endowments/intensities model, less attention has been focussed on the models emphasizing intra-industry trade. Yet, the ideas underlying the new generation of trade models, namely increasing returns to scale and the desire for variety in both production and consumption, are now coming to play increasingly important roles in a wide variety of research areas. This paper attempts to quantify the growing importance of trade based on these factors and extensively tests the models which make predictions concerning intra-industry trade.

The growth over the last 30 years in international trade amongst the OECD nations has coincided with the convergence of per capita incomes in those countries. While the convergence fact has been well researched,[1] two important questions have received less attention. First, what role has resource convergence played in the income convergence of the OECD nations? Second, to the extent that the resource bases of the OECD nations have converged, why has trade amongst them grown so rapidly? The standard Heckscher-Ohlin-Samuelson (H-O-S) trade theory predicts that as nations' resource endowments become less disparate trade volumes should fall. The evidence that is presented in this paper suggests that resource convergence has indeed taken place and that this has led to an increase in intra-industry trade as well as convergence of per capita incomes.

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[1] See for example Baumol and Wolff (1988), De Long (1988) and Dowrick and Nguyen (1989).

The existence and growth of intra-industry trade also bears on a number of other important issues in macro and international economics. Many of the new generation of growth models are predicated on a production function in which the number of varieties of inputs plays an important role. The greater the number of varieties, holding the total level of input constant, the higher is output. Intra-industry trade in differentiated intermediate goods increases the number of varieties available to each producer. This has a level effect on output and, once imbedded into a dynamic model, may increase the steady state growth rate of the economy by increasing the marginal productivity of capital.[2]

Intra-industry trade also impinges on the question of the pass-through of exchange rate changes into domestic prices. As countries become less specialized in the industrial structure of their international trade, and trade in differentiated products increases, questions concerning market structure become more important. As a consequence, the pass-through of exchange rate changes into domestic prices may become slower and more variable. This in turn has implications for both the speed of current account adjustment to exchange rate changes and the size and volatility of exchange rate movements.

Unlike most empirical studies of the predictions of trade theory this paper employs data in both the cross-section and time series domains. Few empirical studies exist on the relationship between changes in resource endowments over time and changes in trade patterns. The studies that have been undertaken focus on the H-O-S model, examining the impact of changes in resource distribution on comparative advantage. Stern and Maskus (1981) and Heller (1976) performed variants of tests of the H-O-S model for the United States and Japan respectively, finding mild support for the theory. In contrast, Bowen (1983) found support for the H-O-S theory in cross-sections for various years between 1963 and 1975 but no support in the time series domain.

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[2] Such a result can be derived by internationalizing the model presented in Romer (1987). A production function similar to that above also plays a central role in the international endogenous growth models developed by Grossman and Helpman (1988). For further work on the links between trade in intermediate goods and economic growth see Lowe (1991).

A number of authors have conducted studies of intra-industry trade in *manufactures* for a particular country or cross sections of countries at a point in time.[3] The theoretical models, however, make predictions concerning trade in *all* industries, not just manufacturing. Helpman (1987), in the most detailed study of intra-industry trade over time, uses all 4 digit SITC categories. He reports a negative correlation between the share of intra-industry trade for 13 nations and the dispersion in their per capita incomes. He does not, however, explicitly address the relationships between similarity of factor endowments and intra-industry trade. In this paper we use data on five resources together with 3 digit SITC trade data (238 "industries") for 22 of the OECD nations for the period 1965 to 1987 to test these relationships.

Section 2 of the paper discusses the convergence of resource endowments amongst the OECD nations and the importance of resource convergence for income convergence. Section 3 surveys the principal models of intra-industry trade and details the importance and growth of this type of trade over the period 1965 to 1987. This is followed in Section 4 by testing of the intra-industry trade models. Finally, Section 5 summarizes the principal findings of the paper.

2. RESOURCE AND INCOME CONVERGENCE

We focus on five resources: labour, skilled labour, capital, agricultural land and natural resources. The endowments of each of the last four resources are divided by the labour force to obtain a measure of resources per worker. The labour supply is measured as the number of economically active people. Skilled labour is the number of workers who fall into International Standard Classification of Occupations (ISCO) classes 0, 1 and 2. Such workers include "professional, technical and related workers" and "administrative and managerial workers". The principal measure of the capital stock is calculated by cumulating investment over a fifteen year period assuming a depreciation rate of 5 per cent per annum.[4] The endowment of agricultural land is

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[3] See for example Aquino (1978), Caves (1981), Grubel and Lloyd (1975), Loertscher and Wolter (1980).

[4] The capital stock was also calculated using a depreciation rate of 13 per cent per annum. No significant differences in the results using the two measures were found.

measured as the number of hectares of arable land and land under permanent crops. To obtain a measure of a country's natural resource endowment we use yearly production data for five raw materials: oil, coal, copper, iron ore, and zinc (see data appendix).

In order to formally test the convergence propositions we estimate the following equation for each relative resource endowment:

$$(Growth\ Rate)_i = \beta_0 + \beta_1(Log\ Initial\ Level)_i + \varepsilon_i \qquad (1)$$

If convergence in relative factor endowments has occurred the growth rate should be negatively correlated with the initial level.[5] Given possible measurement error in the initial values both ordinary least squares (OLS) and instrumental variable (IV) estimates are presented for the capital/labour and skilled labour regressions. For each equation the instrument used is the log of initial per worker GDP. The estimation results are reported in Table 1. Results are not reported for the natural resource/labour ratio as they are dominated by very large changes in the resource ratio in just a couple of countries. An examination of the coefficient of variation for the natural resources/labour ratio does, however, show an upward trend through time.

Two sets of results are reported for the capital/labour ratio. The first uses the capital stock measure obtained from cumulating investment. The second uses direct measures of the capital stock for several sectors as calculated by the OECD. This second measure of the capital stock is, however, only available over the period 1970-1985 and for a subset of fourteen nations.

Using the full set of countries the coefficient on the initial level of the capital stock is negative and significant for both the OLS and the IV estimates. The results for the sectoral capital/labour ratios are mixed. There is strong evidence of convergence of the capital/labour ratios in the agricultural sector over the period 1970 to 1985. The results for the manufacturing sector are less strong but still suggestive of convergence. In contrast, there is little evidence of any tendency for countries with low initial capital/labour ratios in the

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[5] Quah (1990) argues that even if the variance has remained unchanged through time such a regression will yield a negative coefficient on the initial level due to the "regression to the mean phenomenon". The coefficients of variation for the capital-labour ratio, skilled labour ratio and income per worker each show a downward trend over the period supporting the hypothesis that there has indeed been some convergence.

Table 1: Regression Tests of Convergence in Resources

	PERIOD	β_{OLS}	β_{IV}	$\bar{R}^2_{OLS}$	$\bar{R}^2_{IV}$	N
1. CAPITAL/ LABOUR RATIO	1965-85	**-0.99** (5.13) [4.80]	**-1.00** (4.87) [4.84]	0.52	0.52	22
2. CAPITAL/ LABOUR RATIO						
(a) Manufacturing	1970-85	**-0.60** (2.37) [2.94]	**-0.86** (1.36) [1.59]	0.32	0.20	14
(b) Agriculture	1970-85	**-1.46** (6.89) [3.48]	**-1.25** (2.85) [2.85]	0.78	0.76	14
(c) Mining	1970-85	**-0.29** (0.45) [0.81]	**-0.40** (0.45) [0.60]	-0.08	-0.09	11
3. SKILLED LABOUR RATIO	1965-85	**-0.48** (4.27) [3.97]	**-0.49** (3.90) [3.48]	0.45	0.45	22
4. LAND/ LABOUR RATIO	1965-85	**-0.06** (3.36) [3.37]		0.34		22

NOTES
1. The dependent variable is the growth rate and the explanatory variable is the log of the level in the first year of the period. A constant (not reported) was also included in the estimated equation.
2. The instrument used is the log of the initial value of GDP per worker.
3. Absolute t statistics for the null hypothesis that β equals zero are shown in parentheses ( ). White heteroskedastic robust t statistics are shown in square brackets [ ].
4. Sectoral capital/labour data are only available for a subset of the OECD nations. For the manufacturing and agricultural sectors data for the following countries are used: U.S.A., Canada, Japan, Germany, France, Italy, United Kingdom, The Netherlands, Belgium, Denmark, Norway, Sweden, Finland and Australia. The same list of countries with the exceptions of Germany, France and Belgium are used for the mining sector.

mining sector to experience faster rates of capital accumulation in that sector. These results must be interpreted with a deal of caution due to the small number of available observations. The results for the skilled labour ratio support the hypothesis that relative skilled labour endowments of the OECD nations have converged over the period 1965 to 1985. The results for the land/labour ratio also suggest some convergence but at a very slow rate.

Dowrick and Nguyen (1989) argue that "income convergence where it has occurred does not appear to be the result of variations across countries in the growth of factor inputs; rather it results from a systematic tendency for catching up in total factor productivity". While not disputing some role for the convergence in total factor productivity (TFP), the above results contradict Dowrick and Nguyen's assertion regarding factor inputs. Indeed, it appears that the convergence of capital/labour ratios and skilled labour ratios are an important part of the per worker income convergence phenomenon. To examine this issue in further detail we conduct regressions similar to those of Dowrick and Nguyen. Using a shorter time period we are better able to control for both physical and human capital accumulation.

The results reported in columns (1) and (2) in Table 2 are similar to those reported by Dowrick and Nguyen. Column (1) confirms the convergence in GDP per worker. Column (2) presents the results when the average investment ratio is used to proxy the growth rate in the capital stock. As Dowrick and Nguyen find this ratio has a positive coefficient. More importantly, the coefficient on the initial level of income remains highly significant and negative. This is, however, not the case when the growth rate in the capital/labour ratio (column 3) is used to measure the accumulation of capital per worker. The coefficient on the initial level of income per worker falls substantially and has a heteroskedastic robust t statistic of 1.94, while the coefficient on the growth in the capital/labour ratio is highly significant and positive. Further, when the growth rate in the skilled labour ratio is also included the coefficient on the initial level of income becomes essentially zero, while the two resource variables have positive signs and are significant.

The results suggest that the convergence of the capital/labour and skilled labour ratios have played a critical role in the convergence of incomes per worker in the OECD. We now turn to an examination of the theoretical and

Table 2: Analysis of Convergence of Growth Rates (1965-85)

	1	2	3	4
Log Initial GDP Per Worker	**-0.59** (5.19) [4.63]	**-0.58** (5.62) [6.53]	**-0.13** (1.47) [1.94]	**-0.01** (0.09) [0.07]
Average Investment/ GDP Ratio		**0.02** (2.36) [1.61]		
Growth Rate of Capital/Labour Ratio			**0.36** (7.31) [14.78]	**0.39** (8.00) [15.83]
Growth Rate of Skilled Labour Ratio				**0.19** (1.89) [2.21]
$\bar{R}^2$	0.55	0.64	0.88	0.89

NOTES
1. Dependent variable is the growth rate in GDP per worker over the period 1965 to 1985.
2. A constant (not reported) was also included in the estimated equations.
3. Absolute t statistics for the null hypothesis that β_j equals zero are shown in parentheses ( ). White heteroskedastic robust t statistics are shown in square brackets [ ].

empirical implications of this resource convergence for the structure of international trade.

3. INTRA-INDUSTRY TRADE

(a) Models

There are two principal sets of models of intra-industry trade, both resting on the assumption of imperfect competition. The first, developed by Brander and Krugman (1983) focusses on oligopolistic firms' incentives to price discriminate between countries. It assumes that the same good is produced in two countries and that transportation costs are positive. The producers in each country have an incentive to export to the other country (provided transportation costs are not excessive) at a price below the current price. This incentive arises from the fact that sales in the foreign market yield a higher marginal revenue than domestic sales, even though price is lower, as the exporting firm does not suffer a decline in price on the infra-marginal units. The result is two-way trade in identical commodities.

The second and richer set of models rest on consumer preferences which exhibit a desire for variety and on economies of scale in production. These models were developed by Krugman (1979, 1980), Lancaster (1980) and Ethier (1982). The following is a sketch of the simplest model. It closely follows the exposition in Helpman and Krugman (1985). There are two countries (home and foreign), two industries (X and Y), and two factors (capital and labour). One of the industries (Y) uses a constant returns to scale technology to produce a homogeneous good. The other (X) produces a differentiated good. The production of each variety of the differentiated good requires both a fixed and variable cost. It is assumed that the fixed cost is small enough to allow a monopolistically competitive market structure. Technologies are assumed to be the same in both countries and consumers have identical and homothetic preferences represented by the following utility function:

$$U = \left(\sum_{n=1}^{N} C_{x,n}^{\gamma}\right)^{\frac{\alpha}{\gamma}} C_Y^{1-\alpha} \qquad 0<\gamma<1 \tag{2}$$

Production of the differentiated good is relatively capital intensive and the home country is assumed to be relatively capital abundant. The home country therefore, imports the homogeneous good and is a net exporter of the differentiated good. Predictions concerning net trade are thus the same as in the conventional H-O-S factor abundance model. However, given the desire for variety in consumption, the home country will both import and export varieties of the differentiated good. The result is intra-industry trade.

Denote the share of home income in world income by *s*, and home production of the two commodities by *x* and *y*. Foreign variables are denoted by a star (*). The price of X in terms of Y is the same in both countries and is denoted by P. Assuming balanced trade the volume of trade equals twice the exports of the home country. Given the structure of preferences, home's exports equal foreign's share of world income (s^*) multiplied by the total value of home production of the differentiated good (*Px*). The volume of trade is thus given by:

$$VT_{TOTAL} = 2s^*Px \tag{3}$$

The total volume of intra-industry trade equals twice home's imports of the differentiated good:

$$VT_{IIT} = 2sPx^* \tag{4}$$

The share of intra-industry trade in total trade is thus given by:

$$IIT = \frac{VT_{IIT}}{VT_{TOTAL}} = \frac{s\,x^*}{s^*x} \tag{5}$$

Given the distribution of income (*s* and s^* held fixed) intra-industry trade will be greater the closer is x^* to *x*, i.e. the closer are the outputs of the two country's differentiated goods sectors. These outputs will be closer, the closer are the two country's capital/labour ratios. Thus, the more similar are the resource endowments of two countries the more important should be intra-industry trade. Similarly, the smaller the size of the capital rich country (i.e. the lower is *x*) the more important should be such trade. In the limit if two countries are identical ($s=s^*$ and $x=x^*$) all trade will be in differentiated goods.

When we move from a 2 x 2 x 2 world to a multi-country, multi-industry and multi-factor world, the exact pattern of trade becomes indeterminate. However, just as in the H-O-S model, the factor content of country *i's* imports from *j* will be higher in those factors which in autarky were more expensive in *i* than in *j*. While it is not possible to specify exactly which goods *i* will trade with *j*, the analysis in Helpman and Krugman (1985) suggests two testable propositions concerning the importance of intra-industry trade in a world of more than two dimensions.

> **Proposition 1**: As a group of countries' resource endowments become less disparate over time, the share of intra-industry trade in the within group volume of trade should increase.
> **Proposition 2**: The closer are two countries' factor compositions, the more important should be intra-industry trade in their bilateral trade.

In addition to resource dispersion, the simple model suggested that the smaller the size of the capital abundant country the more important should be intra-industry trade (provided the monopolistic competition assumption remains valid). This prediction does not generalize straightforwardly to a multi-dimensional world. The model, assuming monopolistic competition in the increasing returns to scale sector, is only a parable for reality. In small countries fixed costs may prevent the establishment of any firm. As Caves (1981) argues, large fixed costs may result in only a single world producer in which case there will be no intra-industry trade. Such cases are, however, relatively rare. Relaxing the monopolistic competition assumption allows a more important role for country size than suggested by the simple model. Two propositions regarding size are:

> **Proposition 3(a)**: As the economic size of a group of nations increases, the exploitation of economies of scale is likely to become more pervasive. Providing this does not lead to a further increase in monopolistic production, intra-industry trade should increase.
> **Proposition 3(b)**: The larger the size of the smaller country in bilateral trade the more important should be intra-industry trade in bilateral trade.

These propositions are tested in Section 4.

(b) Measurement

Numerous authors have proposed ways of measuring the importance of intra-industry trade. The simplest and most widely used measure is that proposed by Grubel and Lloyd (1975). Intra-industry trade between countries *i* and *j* as a share of their bilateral trade in industry *k* in year *t* is calculated by:

$$IIT^{t}_{ij,k} = \left[1 - \frac{|X^{t}_{ij,k} - M^{t}_{ij,k}|}{(X^{t}_{ij,k} + M^{t}_{ij,k})} \right] * 100 \qquad (6)$$

where $X^{t}_{ij,k}$ ($M^{t}_{ij,k}$) represents exports (imports) of good *k* by country *i* to country *j* in year *t*. To calculate the proportion of intra-industry trade in total trade, we take a weighted average of the individual industry indices where the weights are the share of the industry in total trade. This paper uses 3 digit SITC data so that k = 238. If there is complete specialization across countries the index takes a value of zero. Alternatively, if exports equal imports in all industries the index takes a value of one and all trade is said to be intra-industry trade.

As Aquino (1978) pointed out this measure is biased when aggregate trade is not balanced. Numerous corrections have been applied in an attempt to correct for the bias; however, as Helpman (1987) argues, these corrections are inadequate as the nature of the bias depends on whether the imbalance is generated by homogeneous or differentiated goods. Consequently, we focus our attention on the above measure of intra-industry trade.

(c) Growth and Importance

The shares of intra-industry trade in intra-OECD trade for each country and for the OECD as a whole are shown in Table 3 for selected years. Overall the importance of intra-industry trade shows a steady increase over the period 1965 to 1979, interrupted only in 1974 by the effects of the oil crisis. In contrast, the period between 1979 and 1985 saw no growth in the importance of intra-industry trade, its share in total trade falling by one percentage point over the period. The latest available data suggest an increase over 1986 and 1987. There are significant differences in both the level and growth rate of intra-industry trade across nations. Such trade is highest in the western European nations (Austria, Belgium, France, Germany, Netherlands,

Table 3: Intra-Industry Trade as a Percentage of Total Intra-OECD Trade

	1965	1970	1975	1980	1985	1987
CANADA	27	37	40	42	47	50
USA	24	32	34	35	37	39
JAPAN	13	19	17	19	19	21
AUSTRALIA	6	5	7	8	9	12
NEW ZEALAND	2	4	6	10	13	16
AUSTRIA	30	36	39	48	50	52
BELGIUM	40	44	50	50	50	51
DENMARK	23	31	33	37	37	39
FINLAND	10	21	24	28	29	30
FRANCE	39	46	50	51	50	52
GERMANY	37	44	47	50	50	52
GREECE	4	7	11	11	13	16
IRELAND	24	30	34	38	38	39
ITALY	31	38	38	40	41	43
NETHERLANDS	38	43	43	45	45	49
NORWAY	20	27	28	29	23	27
PORTUGAL	10	14	17	18	23	26
SPAIN	12	18	23	31	34	39
SWEDEN	28	35	35	42	41	43
SWITZERLAND	33	38	41	49	49	50
TURKEY	3	3	3	4	11	15
UK	27	35	41	46	45	48
ALL NATIONS	28	35	38	41	41	43

Switzerland and the United Kingdom) and Canada where it accounts for approximately 50 per cent of total trade. In a number of these countries the share of intra-industry trade has, however, shown little increase over the last 10 years.

Of all the OECD nations Australia has the most highly specialized intra-OECD trade pattern with intra-industry trade accounting for just 12 per cent of total trade in 1987. Australia is closely followed by Turkey (15 per cent in 1987) and New Zealand and Greece (16 per cent in 1987). The degree of specialization in Japanese trade is also low compared to that of most other OECD countries. The other striking observation concerning Japanese intra-industry trade is its failure to increase in the 1970s and first half of the 1980s. In 1969, intra-industry trade's share of total trade was just 19 per cent. Seventeen years later the share was the same. In Section 4 we return to the reasons for this low and static share.

In the 1980s, it has been the less wealthy nations that have experienced the most rapid increases in intra-industry trade. Turkey increased its share by 11 percentage points between 1980 and 1987, Spain and Portugal by 8 percentage points, New Zealand by 6 and Greece by 5 percentage points. These increases compare with a 2 percentage point increase for the OECD as a whole.

Table 4 presents the weighted average share of intra-industry trade for each of the 1 digit SITC categories for each country for 1987. The table shows that there is significant variation across SITC classes. As expected intra-industry trade is least important in those industries which are thought of as producing relatively homogeneous goods - i.e. mineral fuels and crude materials. Intra-industry trade is most important in chemicals (SITC 5) where in 1987 it accounted for 55 per cent of total trade. The importance of intra-industry trade in the other three manufacturing sectors (SITC 6-8) is just slightly lower at around 50 per cent.

The last two rows of the table show the increase in intra-industry trade over time in the different sectors. Over the entire period from 1965 to 1987 chemicals (SITC 5), manufactured goods classified chiefly by materials (SITC 6) and food and live animals chiefly for food (SITC 0) achieved the greatest increases. In the ten years to 1987, over which the share of intra-industry trade increased only slightly, chemicals and food products were the two

Table 4: Intra-Industry Trade by SITC Classes for 1987

SITC CLASS	0	1	2	3	4	5	6	7	8	9	ALL
CANADA	36	14	24	15	25	45	40	66	50	34	**50**
USA	20	7	19	16	27	52	35	41	45	49	**39**
JAPAN	8	7	4	2	29	49	30	17	37	72	**21**
AUSTRALIA	9	34	3	6	14	11	13	10	18	34	**12**
NEW ZEALAND	11	49	4	16	15	18	24	15	29	1	**16**
AUSTRIA	25	38	24	30	11	52	60	54	52	40	**52**
BELGIUM	46	50	36	31	48	65	56	47	65	42	**51**
DENMARK	17	23	27	49	23	44	45	46	47	47	**39**
FINLAND	20	15	9	16	24	36	27	35	43	25	**30**
FRANCE	32	22	29	27	38	57	62	57	53	49	**52**
GERMANY	33	25	28	17	60	63	61	51	51	83	**52**
GREECE	9	20	18	29	26	11	30	6	11	74	**16**
IRELAND	26	37	19	19	19	42	53	36	55	39	**39**
ITALY	19	35	19	24	23	52	53	56	28	8	**43**
NETHERLANDS	33	32	27	17	52	61	62	54	61	61	**49**
NORWAY	12	12	27	15	36	50	28	32	25	41	**27**
PORTUGAL	15	23	9	36	8	28	33	32	16	27	**26**
SPAIN	18	36	21	36	7	44	50	44	34	33	**39**
SWEDEN	30	17	14	39	51	57	43	45	45	61	**43**
SWITZERLAND	26	11	21	6	27	58	60	46	53	33	**50**
TURKEY	4	2	15	14	16	17	19	24	3	8	**15**
UK	29	43	22	17	16	61	47	54	64	44	**48**
ALL NATIONS	27	25	21	19	33	55	50	46	47	52	**43**
% OF TRADE	7.3	1.3	5.1	4.7	0.3	10.1	17.0	40.7	11.8	1.8	
Δ1965-1987	16	13	6	2	13	16	17	10	10	8	**15**
Δ1976-1987	8	3	4	0	-1	7	4	0	3	-4	**4**

0. Food and live animals chiefly for food.
1. Beverages and tobacco.
2. Crude materials, inedible, except fuels.
3. Mineral fuels, lubricants and related materials.
4. Animal and vegetable oils, fats and waxes.
5. Chemicals and related products.
6. Manufactured goods classified chiefly by material.
7. Machinery and transport equipment.
8. Miscellaneous manufactured articles.
9. Not elsewhere classified.

industry groups which achieved the largest increases. Food products was the only one digit category where all countries experienced an increase. The increase in the chemicals category was largely concentrated in those countries whose trade patterns have traditionally been relatively specialized.

4. EMPIRICAL TESTS OF INTRA-INDUSTRY TRADE MODELS

In this section we turn to testing the propositions discussed in Section 3. We conduct tests on two different data sets. The first uses the time series on the share of intra-industry trade in total intra-OECD trade. The second examines the importance of intra-industry trade in bilateral trade by using both cross section and time series data. The tests use data for the period 1965-85.

Propositions 1 and 3(a) suggested that the share of intra-industry trade in the within group volume of trade should be negatively correlated with resource dispersion and positively correlated with economic size. These propositions are tested by regressing the share of intra-industry trade in total intra-OECD trade on the weighted coefficient of variation for each resource ratio and on the log of OECD aggregate GDP (the coefficient of variation for the land/labour ratio is excluded as it is essentially constant). The results are reported in column (1) of Table 5.

Each of the coefficients on the three resource variables has the expected negative sign, with the coefficients on the dispersion of capital/labour ratios and natural resources/labour ratios being highly significant. This result provides support for Proposition 1 above. The log of OECD GDP also has the expected positive sign. This supports the view that as a group of countries becomes larger in terms of the size of their economies, economies of scale can be more widely exploited with a resulting increase in trade in differentiated products.

Each of the exogenous variables shows some evidence of trending through time. Given the nature of these variables we assume that they are trend stationary rather than characterized by a martingale process with drift. In this case ordinary least squares ensures stationarity of the errors but does not ensure that the residuals are orthogonal to **all** the regressors. To overcome this difficulty we include a time trend in the regression. The results are

Table 5: Intra-Industry Trade and Resource Dispersion

	1	2	3
LAG OF INTRA-INDUSTRY TRADE SHARE			**0.23** (1.27) [1.91]
TIME TREND		**-0.62** (2.66) [3.33]	**-0.37** (1.88) [3.94]
DISPERSION OF CAPITAL/LABOUR RATIOS	**-52.62** (6.17) [10.80]	**-28.63** (2.48) [4.28]	**-23.52** (2.22) [3.45]
DISPERSION OF SKILLED LABOUR RATIOS	**-12.95** (0.87) [1.17]	**-15.90** (1.26) [2.07]	**-16.76** (1.75) [2.58]
DISPERSION OF NAT. RES./ LABOUR ENDOWMENTS	**-16.74** (2.52) [5.41]	**-18.38** (3.23) [4.80]	**-17.16** (3.75) [6.34]
LOG OF TOTAL OECD GDP	**10.72** (4.26) [6.96]	**34.53** (3.76) [4.93]	**22.52** (2.63) [5.79]
$\bar{R}^2$	0.97	0.98	0.98

NOTES
1. The dependent variable is a time series on the share of intra-industry trade in total intra-OECD trade.
2. A constant (not reported) was also included in the estimated equations.
3. The dispersion measure is the weighted Coefficient of Variation.
4. The sample size is 21 (years 1965-85).
5. Absolute t statistics for the null hypothesis that β equals zero are shown in parentheses ( ). Heteroskedastic and serial correlation robust t statistics are shown in square brackets [ ].

reported in column (2). Qualitatively, they are the same as those reported in column (1). The three resource dispersion indices have negative coefficients and the size variable a positive coefficient. The coefficients on skilled labour and mineral resources are essentially unchanged while the coefficient on the capital/labour ratio is reduced by nearly 50 per cent.

The estimated equation is a static relationship. We might expect that the impact of changes in resources on trade patterns would not always be completed within the year. The standard errors reported in square brackets are robust to the serial correlation that this slow adjustment may induce. It is of interest, however, to estimate the dynamic effects of changes in resource dispersion on the structure of international trade. Unfortunately, the limited amount of data restricts us to very simple specifications. In column (3) we report the estimation results when the lagged value of intra-industry trade is included in the estimated equation. Again, the results are qualitatively the same as those in columns (1) and (2). In fact the estimated coefficients do not change substantially from those in column (2). The coefficient on the lagged value of intra-industry trade is positive, with a significance level of 0.07. The relatively small size of the coefficient suggests that much of the adjustment in trade patterns is completed within the year. Further work on the dynamic effects, however, awaits longer time series.

We turn now to an examination of bilateral intra-industry trade. In all there are 231 different bilateral trading pairs in the sample. Data for each of these pairs are used for the years 1965-1985. Pooling the cross section and time series observations there are 4851 observations. As discussed above, theory provides little guide as to the precise specification of the equation to be estimated or to the appropriate estimation technique. Consequently, we use a number of different specifications and estimation techniques to ensure the robustness of our results.

The most general specification is:

$$IIT_{ij}^{t} = \alpha_{ij}^{t} + \beta_{ij}^{t} X_{ij}^{t} + \varepsilon_{ij}^{t} \qquad (7)$$

$$(i=1,..,N;\ j=i+1,..,N;\ t=1,..,T)$$

where IIT_{ij}^{t} is the share of intra-industry trade in total trade between countries i and j in year t and α_{ij}^{t} is an unobservable trading pair, time specific effect. Restrictive assumptions are necessary before this equation can be estimated. The most restrictive set of assumptions that we consider are the following:

$$\begin{array}{lll} A1.1 & \alpha_{ij}^{t} = \alpha & \\ A1.2 & \beta_{ij}^{t} = \beta & \\ A1.3 & E[\varepsilon_{ij}^{t} \mid X_{ij}^{t}] = 0 & \end{array} \tag{8}$$

Under these assumptions pooled OLS, using all 4851 observations, is the appropriate estimation technique.

One of the benefits of pooling time-series and cross-section data is the ability to control for unobservable individual trading pair specific effects. Such factors as peculiar historical relationships or similar cultures may affect the level of integration of two economies and thus the importance of intra-industry trade. In this case we relax the assumption of a common intercept for all trading pairs but maintain the time invariant assumption. Thus:

$$\begin{array}{ll} A2.1 & \alpha_{ij}^{t} = \alpha_{ij} \\ A2.2 & \beta_{ij}^{t} = \beta \\ A2.3 & E[\varepsilon_{ij}^{t} \mid X_{ij}^{1},\ldots,X_{ij}^{T}] = 0 \end{array} \tag{9}$$

If we assume that the trading pair effects are not correlated with the observable explanatory variables the model can be re-written as:

$$\begin{array}{l} IIT_{ij}^{t} = \beta X_{ij}^{t} + \nu_{ij}^{t} \\ \textit{where} \quad \nu_{ij}^{t} = \alpha_{ij} + \varepsilon_{ij}^{t} \end{array} \tag{10}$$

In this case the generalized least squares (GLS) estimator is the appropriate estimator. If instead the specific effects are correlated with the observable independent variables GLS yields biased and inconsistent parameter estimates. In this case the appropriate procedure is to estimate the model with a different intercept for each trading pair. This estimator is known as the "fixed effects" (or "within") estimator (see Hausman and Taylor (1981)). Note that in contrast to the pooled OLS estimator the GLS and fixed effects estimators require strict exogeneity of the X_{ij}^{t}.

In the above specifications we have assumed that the parameters are constant through time. This need not be the case. If there are no specific trading pair effects or the effects are uncorrelated with the independent variables, estimation can be conducted period by period.

Below are reported estimation results under each of the above assumptions. All estimation is carried out under the further assumptions of homoskedasticity and no serial correlation. Hypothesis tests for the fixed effects and the pooled OLS estimates are, however, conducted using covariance matrices which are robust to serial correlation and heteroskedasticity. These covariance matrices are estimated using a panel data extension of the Newey and West (1987) estimator. We allow for unrestricted heteroskedasticity and serial correlation within the residuals for each trading pair but assume that the residuals across trading pairs are independent. Two autocovariances are allowed to be non-zero.

In order to test the propositions concerning differences in factor compositions on bilateral intra-industry trade it is necessary to define measures of the degree of dispersion in two country's resource endowments. Again theory provides little guide. To ensure that the results are not sensitive to the measure chosen we use two different measures of dispersion. These are defined below:

$$D_{ij}^{t}(R) = \left(\frac{R_i^t}{R_i^t + R_j^t}\right)^2 + \left(\frac{R_j^t}{R_i^t + R_j^t}\right)^2 - 1 \qquad (11)$$

$$D_{ij}^{t*}(R) = \left|\frac{R_i^t - R_j^t}{\overline{R^t}}\right| ; \quad \overline{R^t} = \sum_{m=1}^{22}\left[\frac{GNP_m^t}{\sum_{m=1}^{22} GNP_m^t}\right] R_m^t \qquad (12)$$

where R_i^t is the ratio of resource R to labour in country i at time t. The higher either index the greater the difference between the two countries relative endowments of the resource. The results were not sensitive to the index chosen. Below we report results for the D_{ij}^t (R) index.

As discussed above the size of an economy may influence the amount of intra-industry trade that occurs. To test this proposition for bilateral trade flows both the log of the larger country's GDP and the log of the smaller country's GDP are included. If size affects the extent of intra-industry trade by allowing exploitation of economies of scale in a greater number of industries it should be the size of the smaller country which is the more important determinant of intra-industry trade.

If two countries share a common border, economic integration is likely to be more extensive and thus the share of intra-industry trade in total trade may be higher. A dummy variable which takes the value of one if the two countries have a land border and zero otherwise is included in the estimated equation. Also included is an EEC dummy which takes on a value of 1 if both countries are members of the EEC. As before a number of the variables are trending through time. Accordingly, we report estimates both including and excluding a time trend.

Table 6 reports the estimation results under the various assumptions. The first 2 columns report the estimation results under assumptions A1.1-A1.3. The results again provide support for intra-industry trade models. This finding does not depend upon the inclusion/exclusion of a time trend.[6] Three of the four resource variables have significant negative signs as the theory predicts. The greater the difference in two countries' capital/labour ratios, land/labour ratios and skilled labour ratios the smaller is the share of intra-industry trade in the two countries' bilateral trade. The results suggest that the reverse is true for the natural resources/labour ratio. This variable, however, plays relatively little independent role in influencing the importance of intra-industry trade amongst the OECD nations.

The parameter estimates suggest that if a country has three times as much capital per worker as a trading partner the share of intra-industry trade in their bilateral trade would be 7 percentage points lower than if the capital/labour ratios were identical. The impact of a similar 3:1 difference in the skilled labour ratio is slightly smaller while a 3:1 difference in the land/labour ratio would result in an approximately 4 percentage point decline in intra-industry trade compared to the level if the ratios were identical.

Both the size variables have significant positive coefficients with the coefficient on the size of the smaller country being significantly larger than that on the size of the larger country. While the coefficient on the size of the larger

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[6] The results were essentially unchanged when the time trend was replaced by time dummies.

Table 6: Bilateral Intra-Industry Trade

	β_{POOLED}		β_{BW}	β_{FE}		β_{GLS}	
TIME TREND		**0.06** (2.26) [2.27]			**0.51** (14.15) [13.91]		**0.31** (12.67)
CAPITAL/ LABOUR RATIO	**-40.70** (11.49) [12.95]	**-40.05** (11.27) [12.65]	**-42.91** (2.64) [3.06]	**8.12** (2.05) [1.86]	**2.74** (0.70) [0.66]	**-0.91** (0.23)	**0.33** (0.09)
SKILLED LABOUR RATIO	**-35.18** (8.21) [8.53]	**-34.93** (8.16) [8.49]	**-39.94** (2.04) [2.16]	**28.01** (5.51) [4.62]	**18.89** (3.76) [3.24]	**16.83** (3.40)	**15.74** (3.22)
NAT. RES./ LABOUR RATIO	**4.59** (5.02) [4.76]	**4.46** (4.87) [4.62]	**7.39** (1.63) [1.55]	**-4.94** (7.16) [6.47]	**-3.81** (5.59) [5.03]	**-4.28** (6.01)	**-4.03** (5.84)
LAND/ LABOUR RATIO	**-25.18** (19.67) [20.24]	**-24.84** (19.27) [19.77]	**-26.06** (4.68) [4.89]	**-32.37** (4.47) [4.22]	**-5.75** (0.78) [0.73]	**-30.06** (7.18)	**-13.85** (3.17)
$LN(Y_{MAX})$	**0.79** (5.22) [5.27]	**0.77** (5.08) [5.14]	**0.79** (1.20) [1.23]	**1.10** (1.73) [1.59]	**-5.58** (7.11) [6.45]	**1.51** (3.30)	**-1.12** (2.24)
$LN(Y_{MIN})$	**6.39** (30.41) [33.33]	**6.29** (29.38) [30.16]	**6.42** (6.97) [7.43]	**11.08** (16.07) [14.88]	**4.05** (4.82) [4.69]	**9.49** (18.77)	**4.86** (7.82)
BORDER	**17.98** (31.24) [25.75]	**18.06** (31.33) [25.84]	**17.70** (7.16) [5.88]			**19.36** (8.12)	**22.51** (9.37)
EEC	**7.57** (19.78) [18.91]	**7.59** (19.83) [19.02]	**7.60** (4.64) [4.54]			**6.88** (4.25)	**7.90** (4.86)
$\bar{R}^2$	0.523	0.524	0.545	0.282	0.287	0.310	0.309
No. Obs.	4851		231	4851		4851	
TEST-NL	0.04 {0.84}	0.04 {0.84}	TEST: $\beta_{BW}=\beta_{FE}$	104.19 {0.00}			

1. A constant (not reported) was also included in all equations except for the "fixed effect" equation.
2. Absolute t statistics for the null hypothesis that β_j equals zero are shown in brackets ( ). Heteroskedastic and serial correlation robust t statistics are shown in square brackets [ ] (see text).

partner is statistically significant it does little to explain the variation in the extent of bilateral intra-industry trade. Increasing the size of the larger country from 25 per cent of the OECD average to the OECD average increases intra-industry trade by just 2.2 percentage points. In contrast increasing the size of the smaller country by the same amount increases intra-industry trade by approximately 10.5 percentage points. This provides support for Proposition 3(b).

The coefficients on both the Border and EEC dummies are positive and significant. The existence of a land border between two countries is an important determinant of the extent of intra-industry trade. After controlling for resource differences and size, the existence of a land border increases the share of intra-industry trade by approximately 18 percentage points. Membership of the EEC increases the share of intra-industry trade by a further 7 to 8 percentage points.

The theory provides little guide as to the functional form of the equation to be estimated. The relationship between the dispersion indices and intra-industry trade is conceivably non-linear. Under the null hypothesis that the specification is correct:

$$E[IIT \mid X \ \ W] = X\beta \tag{13}$$

where X represents the independent variables included in the estimated equation and W all other variables. Under the null, all functions of the form $\theta(W,\pi)$ should be orthogonal to the residuals ($\hat{\varepsilon}$) and thus:

$$\hat{\gamma} \equiv T^{-1} \sum_{t=1}^{T} \hat{\theta}' \hat{\varepsilon} \overset{p}{\rightarrow} 0 \tag{14}$$

An obvious test for nonlinearity is to test this orthogonality assumption for various functions of X and β. Of the many possible candidates we report results for $\hat{\theta}=(X\hat{\beta})^2$ (TEST-NL in Table 6). The reported test is a standard LM test and is robust to heteroskedasticity and serial correlation. The results indicate that the orthogonality condition cannot be rejected. Broadly similar results were found using other functional forms. These tests suggest that the support for the intra-industry trade model does not rest on the linearity assumption.

The third column presents the results using the "between" estimator (β_{BW}). This estimator removes all time series variation from the data by taking the time average of all the variables. The sample size is thus 231. The results are broadly similar to those in the first 2 columns.

We now explicitly allow for trading pair specific effects. The fixed effects estimates are reported in columns 4 and 5. Unlike the earlier results they provide only weak support for the theory. While the natural resources and land variables have the theoretically correct sign, both the capital and skilled labour variables have the incorrect signs. This result is unchanged by the inclusion of a time trend, although the coefficient on the capital/labour becomes insignificantly different from zero. These results suggest that, at the level of bilateral trade, *changes* in resource endowments do not do particularly well in explaining *changes* in intra-industry trade over time. The results using the GLS estimator, which includes the specific effects in the error structure rather than as constants, are similar to the fixed effects results.[7] The table also reports the results of a Hausman specification test of the null hypothesis that $\beta_{BW}=\beta_{FE}$. The hypothesis is overwhelmingly rejected.

There are a number of possible explanations for these poor results. An examination of Table 3 shows that the variation in intra-industry trade across nations is considerably greater than the variation across time in individual countries. The fixed effects estimator does not make use of this variation in mean levels across countries. Instead, it uses the smaller variation across time. In contrast, the between estimator uses the variation in mean levels across countries ignoring any time variation. Other possible explanations for the poorer results in the time domain are the susceptibility of the fixed effects estimator to errors in variables and the difficulty of capturing the correct dynamics.

The above estimations were conducted under the assumption that the parameter estimates are constant through time. Previous work by

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[7] Given the relatively poor results from the fixed effects estimator, the poor GLS results are hardly surprising. The GLS estimator can be interpreted as a weighted average of the fixed effects and between estimators. Given that the time series variation is much smaller than the cross sectional variation, the standard error of the regression is much smaller for the fixed effects estimator. Consequently, the fixed effects estimator receives a much larger weight in the construction of the GLS estimator than does the between estimator.

Helpman (1987) questions the validity of this assumption. Hence, we estimate the equation using each year as a separate cross section. The results for selected years are shown in Table 7. While a number of the parameter estimates appear to be trending through time it is not possible to reject the null hypothesis that the parameters are constant through time (TEST1). It is, however, possible to reject the null hypothesis that the coefficients are the same in 1965 and 1985 (TEST2).

The results again provide support for the propositions discussed in Section 3(a). In each period the coefficients on the capital/labour, skilled labour and land/labour ratios have the correct sign and the vast majority are significant at conventional significance levels. As in the case of the pooled regression results (presented in Table 6) the coefficient on the natural resource variable is the incorrect sign. It is, however, insignificant in most periods and plays little independent role in explaining variations in intra-industry trade across countries. This is particularly the case in the later years.

An examination of the $\bar{R}^2$'s for the various years shows no significant deterioration in the fit of the equation through time. This is in sharp contrast to the model estimated by Helpman (1987). Using a similar specification to that used here, he proxied resource dispersion by differences in per capita incomes. While his model fit reasonably well for the first year of his sample (1970 - with an $\bar{R}^2$ of 0.254) it had collapsed by the final year (1981 - all coefficients were insignificant and the $\bar{R}^2$ had fallen to 0.039). This result led Helpman to conclude that the link between the share of intra-industry trade and differences in factor composition had weakened through time. The results in Table 7, however, suggest that this conclusion is not justified. Measuring relative resource endowments more accurately, we find that the link between resource dispersion and intra-industry trade remains strong.

In Section 3 it was noted that the share of intra-industry trade in Japanese trade has been low and static. It has been suggested that this may be evidence of a protectionist trade and development policy. Numerous authors have also noted that for Japan the share of imports in GDP is relatively low. Estimating import penetration equations, Lawrence (1987) and Balassa and Noland (1988) find that Japan significantly under imports. They interpret this as evidence of protectionist trade policy. However, not all studies have reached this conclusion. Bergsten and Cline (1987) find that import

Table 7: Bilateral Intra-Industry Trade: Time Varying Parameters

	Capital	Skill	Land	Natural	Y_{max}	Y_{min}	Border	EEC	$\bar{R}^2$	JPN
1965	**-14.88**	**-35.82**	**-20.65**	**7.87**	**0.68**	**6.95**	**15.56**	**4.92**	**0.54**	**-3.07**
	[1.27]	[2.41]	[4.90]	[2.09]	[1.25]	[8.30]	[5.63]	[3.04]		[1.99]
1967	**-26.84**	**-33.36**	**-21.65**	**5.23**	**0.69**	**6.72**	**15.17**	**6.29**	**0.52**	**-0.26**
	[2.21]	[2.88]	[4.39]	[1.30]	[1.19]	[7.69]	[4.97]	[3.40]		[0.15]
1969	**-30.34**	**-32.13**	**-23.11**	**2.62**	**0.49**	**6.82**	**17.11**	**6.04**	**0.50**	**-1.09**
	[2.59]	[1.95]	[4.32]	[0.60]	[0.75]	[7.27]	[5.62]	[3.15]		[0.59]
1971	**-35.58**	**-35.29**	**-24.85**	**6.73**	**0.57**	**7.21**	**17.49**	**6.24**	**0.52**	**-1.27**
	[2.57]	[1.77]	[4.38]	[1.57]	[0.86]	[7.73]	[5.82]	[3.58]		[0.52]
1973	**-30.16**	**-47.07**	**-26.22**	**4.73**	**0.60**	**6.90**	**17.46**	**7.15**	**0.53**	**-3.30**
	[2.59]	[2.68]	[4.79]	[1.07]	[0.89]	[7.56]	[6.04]	[4.05]		[1.71]
1975	**-37.48**	**-44.30**	**-28.53**	**8.75**	**0.79**	**6.28**	**18.95**	**8.26**	**0.53**	**-3.88**
	[2.46]	[2.27]	[5.08]	[2.08]	[1.13]	[6.63]	[6.20]	[4.80]		[1.99]
1977	**-51.83**	**-49.37**	**-27.99**	**6.00**	**0.62**	**6.12**	**19.49**	**8.43**	**0.51**	**-4.83**
	[3.26]	[2.38]	[4.72]	[1.32]	[0.86]	[6.16]	[5.75]	[4.50]		[2.56]
1979	**-53.54**	**-49.63**	**-28.05**	**4.89**	**0.88**	**6.21**	**18.72**	**8.59**	**0.49**	**-5.23**
	[2.94]	[2.24]	[4.30]	[1.04]	[1.16]	[5.77]	[6.47]	[4.47]		[2.59]
1981	**-56.81**	**-44.78**	**-26.20**	**5.28**	**0.70**	**5.83**	**18.84**	**9.06**	**0.47**	**-7.18**
	[3.36]	[2.13]	[4.16]	[1.09]	[0.99]	[6.08]	[5.35]	[4.59]		[3.54]
1983	**-69.49**	**-37.53**	**-25.21**	**2.41**	**1.02**	**5.49**	**19.08**	**9.64**	**0.50**	**-6.61**
	[3.77]	[1.79]	[3.99]	[0.55]	[1.39]	[5.22]	[6.82]	[5.11]		[2.89]
1985	**-72.24**	**-28.38**	**-22.96**	**0.23**	**1.27**	**5.13**	**20.10**	**10.29**	**0.48**	**-6.96**
	[5.06]	[1.48]	[3.56]	[0.04]	[1.74]	[5.12]	[6.64]	[5.16]		[3.23]

TEST1	0.69 {0.00}	TEST2	3.47 {1.00}	The sample size for each regression = 231

1. Absolute White heteroskedastic robust t statistics for the null hypothesis that β_j equals zero are shown in square brackets [ ].
2. TEST1 is a F test of the hypothesis that the coefficients are constant across time. TEST2 is a test of the hypothesis that the coefficients in 1965 and 1985 are the same. The "p-values" are given in { }.

penetration into Japan is not unusually low after controlling for a number of explanatory variables. Examining the share of intra-industry trade in total trade may be a better way of assessing the extent of protectionist policy. Protectionist policies aimed at restricting competition in certain key sectors may not reduce total imports but should reduce intra-industry trade.

To test whether the share of intra-industry trade in total trade for Japan can be explained by resource dispersion and country size the model is again estimated for each year with the inclusion of a dummy variable for Japan which takes a value of one if Japan is one of the trading partners and zero otherwise. The parameter estimates are essentially unchanged from those in Table 7 and are thus not reported. The last column of Table 7 does, however, report the coefficient on the Japan dummy variable. In each year, the dummy variable has a negative sign, but, up until the late 1970s the coefficient is insignificant. Since the late 1970s the dummy coefficient has increased in absolute size and become significantly different from zero.

These estimates suggest that in the 1960s, and at least the first half of the 1970s, Japan's low share of intra-industry trade could be accounted for by the fact that its resource base was substantially different from that of most of the other OECD nations. However, as its resource base has become more like many of the other OECD nations, the share of intra-industry trade has not increased. The structure of Japan's international trade remains highly specialized. This is consistent with the view that its development policies have been protectionist.

5. CONCLUSIONS

The growth of two-way trade in similar commodities has been a prominent feature of the evolution of international trade over recent decades. The results presented in this paper provide the strongest support to date for the theoretical models explaining this phenomena.

At the aggregate level, the growth in intra-industry trade can in large part be explained by the convergence of the resource bases of the OECD nations. This resource convergence has not only played an important role in changing international trade patterns but also has been instrumental in the convergence of per capita incomes amongst the member nations of the OECD.

Using direct measures of differences in resource endowments we also find strong support for the differentiated goods intra-industry trade model in cross sections of trading pairs. The greater the difference in the relative resource endowments of two countries the less important is intra-industry trade in their bilateral trade. The model, however, performed less well in explaining changes in bilateral trade patterns over time. This could well reflect the size and importance of shocks external to the model which influence bilateral trading relationships and the difficulty in satisfactorily modelling dynamics.

With the concepts of desire for variety and increasing returns to scale coming to play increasingly important roles in many areas of economics, the results in this paper are comforting. The models based on these concepts appear to have significant power in explaining international trading relationships. While the theoretical importance of these concepts for models of economic growth and the role of international trade in the growth process are now coming to be understood, empirical support awaits further research.

DATA APPENDIX

1. TRADE STATISTICS

Intra-industry trade indices are calculated using the 238 SITC 3 digit classifications (Revision 2). These data were obtained from the OECD's international trade database for the years 1965 to 1987.

2. RESOURCES

(a) Capital Stocks

The primary measure of the capital stock used is calculated by cumulating gross investment over the previous fifteen years with a depreciation rate of 5 per cent per year. The investment data are from Summers and Heston (1988) and are constant price estimates.

The measures of sectoral capital stocks are from the OECD International Sectoral Databank.

(b) Labour Force

The labour force is measured as the number of economically active people and is taken from the OECD Labour Force Statistics. The sectoral labour force statistics are from the OECD International Sectoral Databank.

(c) Skilled Labour

The share of skilled labour in the labour force was estimated using data from the ILO Year Book of Labour Statistics. Skilled labour is defined as International Standard Classification of Occupations categories 0, 1 and 2 which consist of "professional, technical and related workers" (categories 0 and 1) and "administrative and managerial workers" (category 2). These data are not available for all countries for all years. Where observations were missing the share of skilled labour in total labour was estimated by regressing the available data for that country on a constant and a time trend and then using the predicted value for the missing year.

(d) Agricultural Land

The endowment of land is measured by the number of hectares of arable land and land under permanent crops. The data are from the FAO Production Yearbook for 1989.

(e) Natural Resources

The mineral resource index is created by summing the value of production of the following five resources: crude oil, hard coal, copper, iron ore and zinc.

The following are the descriptions and sources for the price and production data. Each price is deflated using the USA GDP deflator.

Crude Oil

Production: OECD - Energy Statistics and Main Series from 1960
Prices: World Bank - Commodity Trade and Price Trends 1987-88: Average US$/barrel OPEC official selling price.

Hard Coal

Production: OECD - Energy Statistics and Main Series from 1960
Prices: World Bank - Commodity Trade and Price Trends 1987-88: The f.o.b US$/metric ton export unit value of bituminous coal at US ports.

Copper

Production: United Nations - Yearbook of Industrial Statistics, Volume II, (various years).
Prices: IMF - Primary Commodities Market Developments and Outlook (1986): US cents per pound on London metal exchange (c.i.f at UK ports).

Iron Ore

Production: United Nations - Yearbook of Industrial Statistics, Volume II, (various years).
Prices: IMF - Primary Commodities Market Developments and Outlook (1986): The c.i.f. US$/metric ton price of Brazilian ore at German ports.

Zinc

Production: United Nations - Yearbook of Industrial Statistics, Volume II, (various years).

Prices: World Bank - Commodity Trade and Price Trends 1987-88: The US$/metric ton.

REFERENCES

Aquino, Antonio (1978), "Intra-Industry Trade and Inter-Industry Specialization as Concurrent Sources of International Trade in Manufactures", *Weltwirtschaftliches Archiv,* 114, 275-296.

Balassa, Bela and Marcus Noland (1988), *Japan in the World Economy,* Institute for International Economics, Washington D.C.

Baumol, William and Edward Wolff (1988), "Productivity Growth, Convergence and Welfare: Reply", *American Economic Review,* 78, 1155-1159.

Bergsten, Fred and William Cline (1987), *The United States - Japan Economic Problems,* Policy Analysis in International Economics, Institute for International Economics, Washington D.C.

Bowen, Harry (1983), "Changes in the International Distribution of Resources and Their Impact on U.S. Comparative Advantage", *Review of Economics and Statistics,* 65, 402-414.

Brander, James and Paul Krugman (1983), "A Reciprocal Dumping Model of International Trade", *Journal of International Economics,* 15, 313-321.

Caves, Richard (1981), "Intra-Industry Trade and Market Structure in the Industrial Countries", *Oxford Economic Papers,* 32, 203-223.

De Long, J. Bradford (1988), "Productivity Growth, Convergence and Welfare: Comment", *American Economic Review,* 78, 1138-1154.

Dowrick, Steve and Duc-Tho Nguyen (1989), "OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence", *American Economic Review,* 79, 1010-1030.

Ethier, Wilfred (1982), "National and International Returns to Scale in the Modern Theory of International Trade", *American Economic Review,* 72, 389-405.

Grossman, Gene and Elhanan Helpman (1990), "Comparative Advantage and Long Run Growth", *American Economic Review*, 80, 796-815.

Grubel, Herbert and Peter Lloyd (1975), *Intra-Industry Trade,* John Wiley, New York.

Hausman, Jerry and William Taylor (1981), "Panel Data and Unobservable Individual Effects", *Econometrica*, 49, 1377-1398.

Heller, Peter (1976), "Factor Endowment Change and Comparative Advantage: The Case of Japan", 1965-69, *Review of Economics and Statistics*, 58, 283-292.

Helpman, Elhanan (1987), "Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries", *Journal of the Japanese and International Economies*, 1, 62-87.

Helpman, Elhanan and Paul Krugman (1985), *Market Structure and Foreign Trade*, MIT Press, Cambridge, MA.

Krugman, Paul (1979), "Increasing Returns, Monopolistic Competition and International Trade", *Journal of International Economics*, 9, 469-479.

Krugman, Paul (1980), "Scale Economies, Product Differentiation, and the Pattern of Trade", *American Economic Review*, 70, 950-959.

Lancaster, Kelvin (1980), "Intra-Industry Trade Under Perfect Monopolistic Competition", *Journal of International Economics*, 10, 151-175.

Lawrence, Robert (1987), "Imports in Japan: Closed Markets or Minds?", *Brookings Papers on Economic Activity*, 2, 517-548.

Loertscher, Rudolf and Frank Wolter (1980), "Determinants of Intra-Industry Trade: Among Countries and Across Industries", *Weltwirtschaftliches Archiv,* 116, 280-293.

Lowe, Philip (1991), "Economic Growth and The Structure of Trade", *mimeo.,* MIT.

Newey, Whitney and Ken West (1987), "A Simple, Positive Definite, Heteroskedasticity and Auto correlation Consistent Covariance Matrix", *Econometrica,* 55, 703-08.

Quah, Danny (1990), "Galton's Fallacy and Tests of The Convergence Hypothesis", *MIT Department of Economics Working Paper,* #552.

Romer, Paul (1987), "Growth Based on Increasing Returns To Specialization", *American Economic Review, Papers and Proceedings,* 77, 56-62.

Stern, Robert and Keith Maskus (1981), "Determinants of the Structure of US Foreign Trade", *Journal of International Economics,* 11, 207-224.

Summers, Robert and Alan Heston (1988), "A New Set of International Comparisons Of Real Product and Price Levels Estimates for 130 Countries: 1960-85, *Review of Income and Wealth,* 34, 1-25.