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Skill Content Tests of Endowment Models of Inter-and Intra-Industry Trade: Evidence for Some High Income Countries

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Abstract

The present study compares the results of factor (skill) content tests for different types of trade flows under alternative assumptions about the technologies used to produce imports and exports. Using data on trade, technologies (skill requirements) and national endowments for some high income countries, we show that the match between the actual factor content of trade and that predicted by endowments in an H-O-V framework improves substantially if technological heterogeneity across countries is allowed for and if the factor content of intra-industry trade (in particular in vertically differentiated goods) is included along with that in inter-industry or net trade.

JEL classification: F11, F14

Keywords: Skill Content Tests, Intra-Industry Trade, Technology Differences …

Outline

Non-Technical Summary

The hypothesis that trade patterns are at least partly determined by relative factor endowments has often been tested using the factor content of commodity trade. The traditional factor content methodology considered only net or inter-industry trade flows, and assumed that common technologies existed across trading partners so that the input matrix of one reference country was sufficient to measure the factor content of trade. This approach reveals trade to embody only relatively small net exchanges of factors when compared with the magnitude of the relative differences in endowments between countries, an outcome Trefler labelled the "mystery of the missing trade". Subsequent empirical work using data on the input requirements of more than one country to calculate the actual factor content of total trade and/or measuring the factor content of intra-industry trade as well as net trade, has found stronger empirical support for an endowments explanation of trade. Here we extend this literature by allowing for product differentiation and distinguishing between the factor content of vertical and horizontal intra-industry trade when testing for the role of endowments in explaining trade flows. Vertical intra-industry involves two-way trade flows of vertically differentiated varieties, and can be explained in terms of differences in the relative factor input requirements of imported and exported varieties and of differences in the relative factor endowments of trading partners, much like inter-industry trade. Intra-industry trade in horizontally differentiated varieties is usually explained in terms of the scale economy motives for specialisation between trading partners with similar factor endowments. One would expect stronger support for a factor content test of an endowments explanation of vertical than of horizontal intra-industry trade flows.

The tests that we employ have become standard in this literature. The *sign test* measures how often the pattern of factor exchange embodied in commodity trade can be predicted on the basis of the trading partners' factor endowments. As its name implies, the *rank order test* compares the ranking of embodied factor trade with the ranking of relative factor abundance. The *slope test* regresses the measured factor content on that predicted by endowment differences. We apply these tests to the trade of the high income Western European countries with 27 middle income and developing countries. Decomposition of intra-industry trade into its vertical and horizontal components requires a high level of disaggregation, and our data sources allow us to use 201 different subsectors of manufacturing industry. The labour force is divided into four skill levels.

Our results confirm that the actual factor content of *all* trade should be measured when exploring an endowments' explanation of trade flows. The tests show that, once technology differences and product differentiation are allowed for, endowments can predict the factor content of both inter- and intra-industry trade flows with a fair degree of accuracy. The match of the measured skill content of vertical IIT flows is similar to that of net or inter-industry trade flows, while endowments have very little explanatory power in accounting for horizontal IIT trade flows. Our results also suggest that differences in the factor requirements of vertically differentiated varieties might play a more important role than differences in factor prices or technology, in explaining differences in factors used in the same sector in different countries.

1. Introduction

There is now a sizeable literature using the "factor content" of commodity trade patterns to "test" the hypothesis that trade patterns are (at least partly) determined by countries' relative factor endowments. The traditional factor content methodology considered only net or inter-industry trade flows, and assumed that common technologies existed across trading partners so that the input matrix of one reference country was sufficient to measure the factor content of trade. This was in part because the empirical methodology related directly to a well-established model - the Heckscher-Ohlin-Vanek (H-O-V) model – whose assumptions implied that outcome. It was in part also empirically convenient because it avoided the need to gather information about input requirements for more than one country. Most studies in fact used the input requirements of the US to measure the factor content of trade with both other developed countries and developing countries.

This study, in line with other recent factor content studies, departs from the HOV approach by allowing for international differences in technology (Trefler, 1995). It also incorporates the implications of product differentiation in internationally traded goods in a way that significantly affects the measurement and interpretation of factor content evidence. In this we follow the recent studies of Hakura (1999; 2001), Davis and Weinstein (2001a,b), and Trefler and Zhu (2000) in measuring the factor content of trade using information on techniques of production from more than one country. We go further, however, by using more disaggregated data on industry and labour classifications and by taking into account the effects of product differentiation on the type of trade flow. This allows us to distinguish between the factor content of inter- and intra-industry trade and between horizontal and vertical intra-industry trade flows.

When subjected to empirical verification by the traditional approach the H-O-V model tends to be rejected. [1] The traditional approach reveals trade to embody only

[1] The studies that presented complete tests to the model using simultaneously data on factor endowments, trade and input requirements (Maskus, 1985; Bowen et al., 1987; Brecher and Choudhri, 1988; Staiger, 1988; Kohler, 1991) reveal contradictory results. A large number of exceptions to the prediction of the Vanek version of the H-O model were found – with the signs and ranks of the net export of factors not matching closely those predicted by the relative factor abundance.

relatively small net exchanges of factors when compared with the magnitude of the relative differences in endowments between countries. Trefler (1995) labels this the "*mystery of the missing trade*". Generalising the model to allow Hicks-neutral differences in technology or differences in demand conditions between countries does contribute to bringing it closer to the data (see Trefler, 1995), but it would be difficult to conclude that allowing for these international differences alone empirically salvages the factor endowments explanation.

Subsequent empirical work has found more empirical support for an endowments explanation of trade. Hakura (1996), for example, uses data on the input requirements of several European countries to calculate the actual factor content of total trade. Davis and Weinstein (2001b) measure the factor content of intra-industry trade as well as net trade and find that *"in half of the rich OECD countries in our sample, intra-industry trade is more important than inter-industry trade in the net export or import of factor services"* and that *"intra-industry trade is in fact one of the principal conduits of net factor trade"* (Davis and Weinstein 2001b, p 17). But while they allow for the existence of exchanges of factors in matched trade flows due to differences in technology or factor prices, they do not consider the role of product differentiation in generating different types of intra-industry trade[2].

Here we draw on the recent literature by allowing technological differences and for factor exchanges in other than inter-industry (net) trade, but also extend it by allowing for product differentiation and distinguishing between the factor content of vertical and horizontal intra-industry trade when testing for the role of endowments in explaining trade flows. Vertical intra-industry trade models (e.g. Falvey, 1981) explain two-way trade flows in vertically differentiated varieties in terms of differences in the relative factor input requirements of imported and exported varieties and of differences in the relative factor endowments of trading partners. Intra-industry trade in horizontally differentiated varieties is usually explained in terms of the scale economy motives for specialisation between trading partners with similar factor endowments (e.g. Krugman, 1979; Lancaster, 1980). One would expect stronger support for a factor content test of an endowments explanation of vertical than of horizontal intra-industry trade flows.

One reason that other recent factor content studies may not have decomposed total intra-industry trade is that they have used relatively aggregated concepts of an industry - typically a disaggregation of trade data close to the 2 digit SIC classification (i.e. about 20

[2] Admitting the latter explanation for differences in factors used in the exports and imports of each industry has important implications for trade- induced adjustment costs, as noted below.

industries). Decomposition of intra-industry trade into its vertical and horizontal components at such a high level of aggregation would be inappropriate. Further, as Feenstra and Hanson (2000) show, aggregation poses important bias problems for the calculation of measured factor content. In the present study we integrate their suggestions using the maximum disaggregation that was possible to match the different data sources. This in the end resulted in 201 different sectors of the manufacturing industry, a level of disaggregation more in line with what is considered appropriate in the intra-industry trade literature.

The rest of the paper is organised as follows. In section 2 the modelling framework is set out for measuring the *actual* factor content of different types of trade in the presence of international technology differences. Section 3 outlines the various factor content tests (*sign, rank and regression tests*) employed and compares these test results for net trade flows only with and without technological differences. For the preferred case of allowance for technological differences, we then in section 4 report the factor content tests for different types of trade flows (*inter- and intra-industry; vertical and horizontal intra-industry*). Finally our summary conclusions are set out in section 5.

2 Factor Content Measurement with International Technology Differences

Studies that use the factor content method traditionally consider the input matrix of factor requirements of only one country to measure the factor content of both imports and exports. This approach assumes that products are homogeneous, there are identical technologies in all countries and that trade leads to factor price equalisation so that identical techniques are employed. The input requirements of exports and imports would then be identical.[3] In this context the net factor content of intra-industry trade (IIT) is zero because the factors embodied in symmetric trade flows are matched. We begin with a HOV equation[4] explaining the factor content of bilateral trade between two countries on the basis of their factor endowment differences. We label the two countries P and U since we later

[3] This is true both in the context of the Heckscher-Ohlin model, which does not predict the existence of IIT, and in monopolistic competition general equilibrium models (Helpman and Krugman, 1985) which assume that all intra-industry trade is horizontal, and production technologies in the differentiated goods sector are identical across countries.

[4] Strictly speaking the bilateral factor content of trade cannot be predicted under the strict assumptions of the HOV setting, namely with factor price equalization. Equation (1) follows the "bilateral comparison" used by Davis and Weinstein (2001b), and is included simply to compare the results obtained in this way with those obtained when other specifications are chosen.

apply this method using factor requirements matrices for Portugal and the UK. The equation is:

$$F_{jUP} = E_{jU} - s_U(E_{jU} + E_{jP}) \quad (1)$$

with $$F_{jUP} = A_U NT_{UP} \quad (2)$$

Here F_{jUP} is the embodied trade in factor j measured from the direct requirements[5] of the bilateral trade between countries U and P, E_{ji} is the endowment of factor j in country i, s_i is the bilateral income share of country i, and A_U is the input requirements matrix used (which is implicitly assumed to be the same in both countries). The vector of trade flows considered in this case is only that of net trade flows in bilateral trade between the two countries (NT_{UP}).

This approach can be modified readily to allow for uniform factor productivity differences between countries. Here the factor endowments are transformed by productivity differences so that they are equivalent in terms of production potential.[6] Introducing this "correction" yields:

$$F_{jUP} = E_{jU} - s_U(E_{jU} + \delta_P E_{jP}) \quad (3)$$

where δ_P is the productivity parameter for country P, and δ_U has been normalised at unity.

Once we drop the assumptions that countries have identical technologies or that industries produce homogeneous goods (and allow imports and exports to represent different varieties produced using different technologies), the importer's input matrix no longer captures the actual factor content of imports. We then need measures based on two different input requirements matrices. For bilateral trade between U and P the equation is:

$$(AF_{jUP})/\psi_{UP} = [E_{jU} - s_U(E_{jU} + E_{jP})] \quad (4)$$

With the actual factor content being measured by:

$$AF_{jUP} = A_U X_{UP} - A_P M_{UP} \quad (5)$$

[5] Several authors (Staiger, 1986; Maskus et al, 1994; Bowen et al, 1987) discuss whether direct factor requirements or indirect factor requirements (including the factors used in the intermediates) should be considered in the calculations of the factor content. We accept the position of Maskus et al (1994), following Staiger (1986), who argue that direct requirements are more appropriate for the case of small open economies that trade intermediate goods freely at world prices, and measure only the direct factor content of UK trade. This is also convenient given data constraints on measuring indirect factor requirements at the level of trade disaggregation used here. See Trefler and Zhu (2000), however, for a discussion of how using direct inputs only may affect the measurement of factor content.

[6] Here the adjustment consists of transforming the available man years of different countries into efficiency equivalent units of man years. A range of proxies were considered to capture productivity differences, including differences in output per worker and per capita GDP. The results reported use differences in average wages in manufacturing across the countries. Results for alternative means of correcting for productivity differences are available from the authors on request.

where X_{UP} and M_{UP} are, respectively, exports of U to P and imports of U from P represented in different types of trade flows (net trade; intra-industry trade; horizontal and vertical intra-industry trade). In (4) each type of trade flow is scaled by the parameter ψ_{UP}, which is the proportion of that type of trade flow in total bilateral trade.[7] Equation 4 can also be subject to a factor productivity correction yielding:

$$(AF_{jUP})/\psi_{UP} = [E_{jU} - s_U(E_{jU} + \delta_P E_{jP})] \quad (6)$$

A technique that can be applied only to a particular bilateral trade flow is of limited interest, and ideally we would like to consider the factor content of all bilateral trades for a range of countries. However, complete information on input requirements for all trading partners is unlikely be available, leaving little choice but to proxy the technologies of most countries. We suggest two ways in which this might be done. Each is based on the notion that countries at similar levels of development have similar technologies. Our first approach is to apply a "representative" matrix for all countries at a similar level of development. Under this approach we apply the UK matrix for all high income developed countries (HID) and the Portuguese matrix for all middle income countries (MID). Our alternative approach is to estimate the matrix for a third country (R) using a linear combination of A_P and A_U where the weights are based on the per capita GDPs of the three countries (i.e. y_j, j = R, P and U). Thus

$$A_R = \theta_R A_U + [1-\theta_R]A_P = \theta_R[A_U - A_P] + A_P \quad (7)$$

where A_R is the estimated input requirements matrix for country R. Assuming that $y_U - y_P > 0$, the weighting parameter θ_R is given by:

$\theta_R = [y_R - y_P]/[y_U - y_P]$, for all countries where $y_R - y_P > 0$; and

$\theta_R = [y_R - y_P]/[y_U - y_R]$, for all countries where $y_R - y_P < 0$.

To implement our factor content measures we need data on trade and skill requirements for a consistent classification of industries and labour skills across countries. We use a classification that considers 201 industries based on the four-digit SIC (Standard Industrial Classification) categorisation. Of the 262 manufacturing industries at this level of aggregation, 165 were taken as the given SIC(4) categories. But to match this with trade

[7] The gross trade between U and P ($X_{UP} + M_{UP}$) is decomposed into net trade ($|X_{UP} - M_{UP}|$), and matched trade ($2\min\{X_{UP}, M_{UP}\}$). Further, matched trade is decomposed into matched trade in horizontally differentiated and vertically differentiated goods using the approach of Greenaway, Hine and Milner (1994, 1995) and Greenaway, Milner and Elliott (1999). Each component is expressed relative to gross trade to provide the relevant scaling parameter (ψ_{UP}) in equation (4).

data from the SITC (Standard International Trade Classification) and the occupations and production data from the Portuguese CAE (similar to NACE/Clio) some sectors had to be aggregated. So the other 97 SIC categories were aggregated into 36 industries.[8]

Data on industrial employment by occupation and qualifications was obtained from the Data Archive Labour Force Survey for the UK, and from the Employment and Labour Statistical Office "Quadros de Pessoal" database, for Portugal. Most of the 89 occupations described in the Portuguese classification (CNP) at the 3 digit level are similar to the 74 occupations used in other studies (e.g. Webster, 1993) based on the UK Labour Force Survey Standard Occupational Classification (SOC). In many cases the higher number of categories of the Portuguese classification corresponds only to a division of the SOC categories into two or more CNP categories, posing no problem to matching the two classifications. But other cases were more complex, resulting in the need to aggregate some labour categories in order to match the Portuguese and the SOC classifications. This generated 59 different labour categories (based on the SOC classification), which were then gathered into 4 categories that correspond to groups of different skill levels. There is no single agreed-upon method of classifying workers according to skill level. The simplest approach is just to consider the separation into two categories (i.e. skilled and unskilled), but other studies consider from 5 to 9 different labour categories.[9] Here we follow the labour economics literature that classifies the level of skills of occupational groups by matching occupational data with education and wage information – e.g. Howell and Wolf (1991), Sachs and Shatz (1994), Berman et al (1994). We group the occupational categories into 4 different skill levels (high, medium, clerical and production).

3. 'Factor Content Tests' With and Without Technological Homogeneity

Cabral, Falvey and Milner (2006) report on the skill content of the UK's trade (with 38 countries for 1995) using the traditional (common technologies) assumption and allowing for inter-country differences in technologies. They show, in line with other studies (eg Davis and Weinstein, 2001a), that allowing for technological differences increases the net exchanges of factors in the UK's trade and helps therefore account for some of the

[8] Details of the matching of are available from the authors on request.

[9] The two studies that report results for a larger number of labour categories also adopt different criteria for aggregating these: Webster (1993) reports the factor content results for 35 different occupational categories and for 5 or 9 groups where these are gathered, while Maskus et al (1994) report results for 74 occupations gathered in 8 different groups.

'missing trade' when the traditional HOV model is applied. Here we concentrate on whether allowing for technological differences increases the predictive power of an endowments explanation of bilateral trade patterns, as found by others (e.g. Hakura, 2001). The term 'factor content testing' is traditionally used to describe the methods applied here. One might question whether they are appropriately described as tests of the model, given that an alternative is not explicitly defined. Here we explore whether there are systematic deviations from randomness in the relationship between the factor content of bilateral trades and national endowments. This may be viewed as a more limited exercise of accounting for the correlation between factor content and endowments rather than testing the HOV model. For convenience, however, we stick with the conventional label of 'factor content tests'.

Sign tests

Sign tests are directly based on the definition of absolute factor abundance. This follows the idea that if trade is balanced (or adjusted to trade imbalance), each country should be a net exporter of the services of its absolutely abundant factors and a net importer of services of its absolutely scarce factors. The sign test compares the signs of the two sides of equation (8):

$$\mathrm{Sign}(F_{jR}) = \mathrm{Sign}(E_{jR} - s_R E_{jw}) \qquad (8)$$

where F_{jR} is the amount of factor j embodied in net exports, E_{jR} is country R's endowment of factor j and E_{jw} is the world endowment of factor j. With data on the factor content of trade and endowments, the test consists in checking how the sign obtained from the data on endowments (right hand side) matches the sign of factor trade (left hand side).

Rank order tests

The rank order test compares the proportionate net trade (adjusted for trade imbalance) in each factor, with the structure of factor abundance measured by the endowments. The test consists in assessing to what extent the ranking of proportionate factor trade of the n factors:

$$F_{1R}/Z_1 > F_{2R}/Z_2 > \ldots > F_{jR}/Z_j > \ldots > F_{nR}/Z_n$$

duplicates the ranking of country *R* shares of the endowment of each factor in world resources:

$$E_{1R}/E_{1w} > E_{2R}/E_{2w} > \ldots > E_{jR}/E_{jw} > \ldots > E_{nR}/E_{nw}$$

The variable Z scales the trade in each factor by the endowment of the factor (the country or the world endowment) or by the country's consumption share in world income. This corresponds to transforming equation (8) by dividing both sides by the world endowment of factor "j". The proportion of correct pairs of rankings among factors and endowments is calculated, or the rank correlation ratio between factors and endowments and its statistical significance is computed.

Any data that strictly satisfy the HOV equation will also satisfy the sign (and the rank) hypothesis. But, as Maskus (1985) and Kohler (1991) note, the reverse is not true. The hypotheses tested in the sign and rank order tests are a weaker version of the strict HOV hypothesis of a perfect match between the factor content of trade and endowments. Kohler (1991) stresses that a violation of these weaker versions implies strong evidence against the HOV model.

Slope tests

An alternative way of testing the factor content equations is to estimate a regression of the measured factor content on the predicted factor content. The HOV equation specifies an exact mathematical relation between the factor content of trade and the excess factor supplies. If the theory was in perfect match with the data the slope of such a regression would be one, with a perfect fit obtained by the equation. To measure the significance of the actual relationship one should use the t-statistic for the estimated slope to test it against a null hypothesis of a zero slope. As Estevadeordal and Taylor (2001, pp 4) note "*this test can detect a positive and significant relationship of endowments to trade, though it need not be one-for-one*".

We apply the above tests to the trade of 5 high income European "countries"[10] with each of 27 middle income and developing countries[11]. For each skill type (described in section 2) we have 135 observations. The data on endowments was obtained from the LABORSTA database of the ILO organisation.[12] This database presents the total number of workers employed in detailed occupational categories for different countries. The data is available for an extensive list of countries and for several years. For most of the countries,

[10] The five countries considered are three large high income European economies (France, Germany, UK) and two regions that are treated as if they were two countries: Benelux (Belgium, Luxemburg and Netherlands) and Scandinavia (Denmark, Finland, Norway and Sweden)

[11] These countries are: Brazil, Bulgaria, Colombia, Costa Rica, Cyprus, Czech Republic, Egypt, Estonia, Greece, Hungary, Malaysia, Latvia, Lithuania, Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Thailand, Mexico, Russia, South Korea, Turkey, and Ukraine.

[12] Data is available on the internet (http://laborsta.ilo.org/cgi-bin/brokerv8.exe).

data following the ISCO-88 classification can be found. This classification was converted into the SOC classification for which we had data available by occupation and industry, necessary to build the input requirements matrices.

The Heckscher-Ohlin theory, in its simpler form, usually considers two (presumed internationally immobile) factors: labour and capital. The present study focuses only in labour skills to explain trade. In doing this we follow the tradition of Keesing (1965; 1966), Findlay and Kierzkowski (1983), Minford (1989) and Wood (1994); who explain trade based exclusively on labour skills and view physical capital as now a relatively mobile factor internationally.

Results for common technologies

In order to provide a base result against which comparisons can be made when we relax particular assumptions, we conduct the tests outlined above first for the case where we adopt the strict HOV model and assume a common technology across countries. We proxy the technology for each of the high income countries using the UK's input requirements matrix, and assume the imports from the middle income and developing countries are produced using that same technology. The results from what might be viewed as the traditional approach are set out in Table 1.

The sign results obtained when the traditional approach to factor content is used to measure and predict the factor content of trade are similar to those of earlier studies, with two of the four skill groups being close to the "coin flip" proportion of correct matches between the measured and predicted factor content (see line 1 of Table 1). The rank and regression tests also confirm what has been found previously about the strict HOV model: the model's predictions fail to match the real world data.[13]

Table 1: Tests for Traditional HOV Equation (common technology case).

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		59%	43%	51%	61%
Rank Test		47%	44%	34%	52%
Regression Test	*Slope*	0.053	-0.014	0.015	0.042
	T-statistic	1.38	-1.08	0.76	1.30
	Significance	0.17	0.28	0.45	0.19

[13] Note that none of the slopes for the regression test are significantly different form zero, and that the slope for the medium skilled labour is negative (contrary to what is expected by the theory: a slope equal to plus one).

Correcting for differences in factor productivity (Table 2) clearly improves the match between measured and predicted factor content. The proportion of correct signs increases for all skill types and becomes significant for 3 of these at a 1% level, while for the HOV original equation this is only true for the low skilled production workers. The slopes in the regression test, although still far from the predicted unity, increase and at least for high skilled labour the slope is different from zero at a significance level of less than 5%. The slope coefficient is also significant at the 10% level in the case of production workers.

Table 2: Tests for Traditional HOV Equation (productivity adjusted).

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		74%	63%	56%	65%
Rank Test		68%	64%	52%	58%
Regression Test	*Slope*	0.141	0.114	0.095	0.164
	T-statistic	2.34	1.53	0.85	1.74
	Significance	0.02	0.13	0.40	0.08

Results for technological heterogeneity

When one considers the actual factor content (i.e. using different technology matrices to measure the factor content of exports and imports), there is an important improvement compared with the results obtained for the strict version of the HOV model. We are now measuring the skill content of exports and imports (as in equation 4) using different technology matrices for exports and imports. The improvement is both in terms of the proportion of the correct signs and ranks, and also in terms of the estimated slopes in the regression tests. The improvement is not as marked, however, if one compares the results of Table 3 with those of Table 2. Using the actual factor content of trade seems to improve considerably the matching for the low skilled workers (both production and clerical), but for the high and medium skill groups the results do not show an improvement when compared with the simple transformation of the strict HOV model of correcting for international productivity differences.

Table 3: Tests for Actual Factor Content (technological heterogeneity without productivity adjustment)

	High Skilled	Medium Skilled	Clerical	Production
Sign Tests	73%	59%	72%	84%

Rank Test		69%	61%	65%	71%
Regression Test	*Slope*	0.177	0.154	0.197	0.296
	T-statistic	1.89	1.73	1.43	2.78
	Significance	0.06	0.09	0.16	0.01

When one measures the actual factor content and also makes the correction for differences in productivity in determining factor abundance, the results become more supportive of a relationship between measured and predicted factor content (see Table 4). The sign and rank tests are all significant at the 1% level and the slopes are different from zero for all skill types at least at a 10% level of significance.

Table 4: Tests for Actual Factor Content (technological heterogeneity with productivity adjustment)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		91%	78%	73%	88%
Rank Test		81%	69%	63%	73%
Regression Test	*Slope*	0.235	0.255	0.166	0.383
	T-statistic	4.21	2.17	1.63	2.86
	Significance	0.00	0.03	0.10	0.00

The use of the estimated matrices, instead of using only the Portuguese and the UK (compare Tables 3 and 4 with Tables 5 and 6), also improves the results with the sign tests improving and the slopes becoming significant, for at least a 5% level of significance, for all the skill types.

Table 5: Tests for Actual Factor Content (estimated technologies without productivity adjustment)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		88%	67%	74%	91%
Rank Test		72%	64%	71%	78%
Regression Test	*Slope*	0.261	0.163	0.232	0.345
	T-statistic	3.14	2.12	1.83	3.54
	Significance	0.00	0.04	0.07	0.00

Table 6: Tests for Actual Factor Content (estimated technologies with productivity adjustment)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		93%	84%	74%	94%
Rank Test		86%	68%	69%	79%

Regression Test	*Slope*	0.335	0.255	0.235	0.372
	T-statistic	4.57	2.17	2.03	3.16
	Significance	0.00	0.03	0.04	0.00

The key conclusion is that allowing for technological heterogeneity either by measuring the factor content of trade using representative or estimated technology matrices improves significantly the capacity of endowments to account for the services of factors embodied in these high income countries' bilateral trade flows with a range of middle income and developing countries. Both approaches give coherent and markedly improved results, when compared to the use of the strict HOV equation. The match between measured and predicted factor content improves when the actual skill content of trade is measured using information about technologies for more than one country.

4. The Endowments - Factor Content Relationship for Different Types of Trade Flows

We apply now the same methodology to different types of trade flows, measuring the actual factor content of trade using the technology matrix of Portugal to represent technology in the middle income and developing countries and that of the UK for the high income countries.[14]

The results show that endowments perform well in predicting the net exchanges of factors both for inter-industry trade (Table 7) and for vertical intra-industry trade where the matched exchanges involve the high income countries exporting higher quality varieties (Table 9). They also show that endowments can still predict with some accuracy the net factor content of total intra-industry trade (Table 8); although, as one would expect, the match between predicted and measured factor content is less accurate than that obtained for inter-industry trade. The main difference occurs with horizontal intra-industry trade. The results show, that at least for the countries studied, no significant relationship can be established between the measured and predicted factor content of horizontal intra-industry trade flows (Table 10).

Table 7 shows the results for the tests applied to the net exchanges of factors embodied in inter-industry trade. Endowments predict the sign of the skill content in more than 75% of the cases for all the categories, and for two of the skill groups for more than 90% of the cases. The slopes obtained for the regression tests for each factor are different

[14] Results are also available (from the authors) when estimated technology matrices are employed. The results are very similar to those reported here and do not alter any conclusions.

from zero with at least a 10% level of significance. For two skill groups a 1% level of significance is achieved. This suggests support for an endowments explanation for these inter-industry trade flows. Endowments explain the measured factor content of trade once one takes into account differences in technologies.

Table 7: Tests for Actual Factor Content of Inter-Industry Trade Flows (with productivity adjustment)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		91%	75%	77%	92%
Rank Test		86%	69%	61%	71%
Regression Test	*Slope*	0.271	0.175	0.240	0.422
	T-statistic	4.14	1.73	2.02	3.61
	Significance	0.00	0.09	0.05	0.00

More surprising are the results in Table 8. These show that endowments also seem to explain the net (skill) factor content of intra-industry trade flows. The match between predicted and measured factor content is poorer than for inter-industry trade flows, with in general lower proportions of matched signs and ranks and with the relationship becoming insignificant for the clerical workers. But for three out of the four types of labour the proportion of matched signs and ranks and the slopes of the regressions are significant. These results are not in accordance with the workhorse model of intra-industry trade (Helpman, 1981; Helpman and Krugman, 1985) in which inter-industry trade is driven by differences in endowments and intra-industry trade by the interaction of product differentiation and scale economies in monopolistic competitive markets. In this framework the share of intra-industry trade in total trade increases as endowment differences decrease between trading partners.

Table 8: Tests for Actual Factor Content of Intra-Industry Trade Flows (with productivity adjustment)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		71%	76%	58%	68%
Rank Test		68%	68%	55%	61%
Regression Test	*Slope*	0.171	0.188	0.130	0.217
	T-statistic	2.18	1.93	1.12	1.73
	Significance	0.03	0.06	0.26	0.09

The explanation for our finding may be that vertical intra-industry trade is the dominant type of matched trade flows, where this type of trade embodies important net exchanges of factors driven by endowment differences. That is supported by the results in Tables 9 and 10. Table 9 shows that the match of the measured factor content of vertical intra-industry trade with the predicted factor content is similar to that obtained for the inter-industry trade flows. The proportion of matched signs is very similar to that obtained for inter-industry trade, with the exception of clerical workers for which endowments perform less well in predicting the skill content of trade.

Table 9: Tests for Actual Factor Content of Vertical Intra-Industry (Higher Quality Exporting by High Income Countries) Trade Flows (with productivity adjustment)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		90%	84%	68%	88%
Rank Test		83%	81%	57%	61%
Regression Test	*Slope*	0.249	0.228	0.169	0.272
	T-statistic	2.64	2.44	1.63	2.32
	Significance	0.01	0.02	0.10	0.02

The fact that endowments seem to predict the net exchanges of factors embodied in inter-industry trade as well as those embodied in vertical intra-industry trade (where the high income countries export varieties of higher quality) is in line with an explanation of vertical intra-industry trade in Falvey (1981) and Falvey and Kierzkowski (1987). These models explain vertical intra-industry trade flows in terms of differences in the factor requirements of different qualities of products; higher quality requiring greater inputs of a specific factor (e.g. human capital) for which endowments differ across countries. Our findings are consistent with high income countries exporting high quality, skill-intensive varieties and importing lower quality, less skill-intensive varieties in a world where higher skills are more abundant in higher income countries[15]. The expected net factor content of this type of trade will be similar to that of inter-industry trade.

Table 10 presents the results of the tests for horizontal IIT trade flows, where endowments have no explanatory capability for the observed measured factor content of trade flows. Matched trade flows classified as horizontal intra-industry trade embody net exchanges of factors that are not related in a significant way to the endowment differences. The proportion of correct signs and rankings are not significant, with most being indistinguishable from randomness (i.e. below the predictive power of a coin toss), and the slopes in all the regression tests are not different from zero. For the case of medium skilled workers the slope is even negative. This pattern is in accordance with what is to be expected from monopolistic competition models of horizontal IIT. These models (Krugman, 1979; Lancaster, 1980) lead us not to expect net exchanges of services of factors embodied in matched trade flows.

Table 10: Tests for the Actual Factor Content of Horizontal Intra-industry Trade Flows (with productivity correction)

		High Skilled	Medium Skilled	Clerical	Production
Sign Tests		53%	43%	46%	49%
Rank Test		45%	39%	44%	42%
Regression Test	*Slope*	0.012	-0.018	0.001	0.021
	T-statistic	0.74	-0.55	0.32	0.35
	Significance	0.46	0.58	0.74	0.73

These results suggest that the apparent inconsistency of the Chamberlain-Heckscher-Ohlin model with previous results for total IIT flows is not because horizontal IIT involves systematic net exchanges of factors, but rather because intra-industry trade involves greater amounts of matched exchanges of vertically rather than horizontally differentiated commodities. The differences in the test results for horizontal and vertical IIT indicates the importance of decomposing intra-industry trade into the two types of trade flows.

The present results are consistent with vertical product differentiation being a significant cause of differences in factor requirements within industries in different

[15] Contrary to this explanation of vertical IIT, we do find some evidence of vertical IIT where the high income countries export lower quality varieties. Fortunately the amount of such trade is relatively small (less than 30% of vertical IIT) and the tests (available from the authors) are much less supportive of an endowments explanation.

countries. As reported also in Cabral, Falvey and Milner (2006), these differences induce substantial net factor exchanges embodied in matched or intra-industry trade flows for the UK. If these differences could be attributed only to non factor price equalization, as has been suggested in most studies that use the actual factor content of trade, there would be no reason to expect them not to assume the same importance in horizontal and vertically differentiated products.[16] This distinction has important implications for the expected adjustment costs induced by trade expansion since it suggests that the imports from low wage countries might be replacing the production of low quality varieties, produced with low-skill labour requirements that are higher than the sector average. Matched trade flows might then induce important labour market disruptions[17].

5. Summary and Conclusions

In line with some other recent studies this study finds that a key assumption of the traditional factor content methodology, namely that the exchange of factor services is only embodied in net or inter-industry trade flows, is not supported empirically. We find there is skill content in the intra-industry trade flows of a range of high income countries, and that the match between measured and predicted skill content (as shown by a range of factor content tests) improves relative to the traditional testing of the H-O-V model. The actual factor content of all trade should be measured when exploring an endowments' explanation of trade flows.

The tests show that endowments can predict with a fair degree of accuracy the factor content of both inter- and intra-industry trade flows, albeit with more accuracy for the former than the latter. This is to be expected where intra-industry trade flows incorporate (matched) two-way trade in both horizontally and vertically differentiated products. The theoretical and empirical literatures (e.g. Durkin and Krygier, 2000) on intra-industry trade provide support for the idea that national endowment differences only play a role in explaining IIT in vertically differentiated goods. When, in the present study, we decompose IIT into these two types, we find that the match between the predicted and

[16] Non factor price equalization means that when minimizing costs producers in each country will tend to use the cheaper factors more intensively. This will mean that factors used in the same sector/industry in two different countries to produce exactly the same product will be used with differing intensities. These differences (attributed only to non-equalization of factor prices) do not depend on product differentiation and the level of quality, but only on the relative prices of factors and the substitutability of factors within each sector.

[17] In contrast, where products are produced using different combinations of factors across countries due to technology and factor price differences, there need be no difference in the factor requirements of the exported varieties and those displaced by imports.

actual skill content of each type of trade is as the literature suggests. The match of the measured skill content of vertical IIT flows is similar to that of net or inter-industry trade flows, while endowments have very little explanatory power in accounting for bilateral, horizontal IIT trade flows. This clearly indicates that there is most support for an endowments explanation of trade where exchanges of an inter-industry and vertical IIT nature can be captured by the empirical analysis. It also suggests that differences in factor requirements of vertically differentiated varieties might play a more important role than differences in factor prices or technology, in explaining differences in factors used in the same sector in different countries. This is an issue worthy of further investigation since it has important implications for the expected adjustment costs induced by trade. The decomposition of trade both into inter- and intra-industry trade and into vertical and horizontal IIT is not unproblematic from an empirical perspective. Industry definition or aggregation problems exist and there is inevitable imprecision associated with a decomposition of total into vertical and horizontal IIT based on the present unit value dispersion methodology. Not withstanding the benefits of further refinement of the measures of the different types of trade flows, the present work indicates that the current decomposition of trade flows is empirically credible and provides increased support for an endowments' explanation of trade.

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