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Endowment Differences and the Composition of Intra-Industry Trade

by

Manuel Cabral, Rod Falvey and Chris Milner

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The Authors
Manuel Cabral is a Professor Auxiliar at the University of Minho, Rod Falvey is Professor of International Economics and Research Fellow in GEP and Chris Milner is Professor of International Economics and Research Fellow in GEP.

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Abstract
This paper investigates the relationship between differences in endowments and different types of trade, in particular vertical intra-industry trade (VIIT). We build a general equilibrium framework based on a hybrid of the Chamberlain-Heckscher-Ohlin and the specific factors models that generates predictions about how the shares of different types of intra-industry and net trade flows change with differences in endowments. We also present some empirical evidence for European Union trade with its 51 major trading partners. The econometric models of the determinants of the different types of trade confirm the theoretical predictions, namely that the effect of cross country differences in the endowments of trading partners on the share of vertical IIT in total bilateral trade differs from their effect on both horizontal IIT and net trade. The share of horizontal IIT (net trade) decreases (increases) for all increases in absolute endowment differences, but the share of vertical IIT can both increase and decrease with increases in endowment differences.

JEL classification: F11, F14

Keywords: Intra-industry trade, factor endowments

Outline

Non-Technical Summary

Factor endowment differences play an important role in international trade theory, for both the pattern and volume of trade. Both the Heckscher-Ohlin and monopolistic competition models predict that the share of net or inter-industry trade in total trade will be larger the greater the differences in relative factor endowments between countries. Monopolistic competition models also involve intra-industry trade (IIT), which is generally assumed to be horizontal (HIIT) in nature, involving the exchange of differentiated varieties of the same good, produced using a common increasing returns to scale technology, and therefore involving no net exchange of factor services. This can be distinguished from matched exchanges of vertically differentiated commodities - vertical intra-industry trade (VIIT) - which involves the exchange of different qualities of the same good, produced using different technologies. Explanations of VIIT involve differences in endowments (between countries) and in factor requirements within each industry.

While theory has focused on HIIT, empirical studies reveal that VIIT is the dominant type of trade for most developed countries, and that VIIT embodies net exchanges of factor services. The presumption has been that VIIT, like net trade (NT), will show a positive monotonic relationship with endowment differences between countries. But existing trade models do not allow us to draw clear inferences about this, and we show that the data suggests a more complex relationship between VIIT and differences in endowments. In order to clarify both the relationship between VIIT and HIIT and that between VIIT and NT, we develop a framework that allows for the simultaneous existence of HIIT, VIIT and NT, from which we are able to draw some testable hypotheses about the relation between endowment differences and the shares of HIIT, VIIT and NT in total bilateral trade. The predictions for HIIT are quite conventional - larger endowment differences would reduce such trade. But the predictions for VIIT are more factor and trading partner specific. VIIT should grow with differences in sector specific factor endowments, as long as these differences remain small. The effects of larger specific factor endowment differences depend on whether the specific factor is used by the industry. If not, then VIIT declines for larger endowment differences. If so, then the share of VIIT increases (decreases) if the trading partner has an ever larger (smaller) endowment.

We test these hypotheses for European Union trade with its 51 major trading partners. Our results confirm that HIIT declines with growing endowment differences. They also confirmed the sensitivity of VIIT flows to the magnitude of endowment differences. The specific predictions on endowment differences in the specific factor used by the industry (assumed to be capital) are also confirmed. But the nonlinearities predicted for the other specific factor (assumed to be land) do not appear, perhaps due to insufficient variability in the sample. Overall these findings support the view that both within and between industry specialization and trade can be driven by factor endowment considerations, and undermine the view that VIIT is simply disguised inter-trade associated with industry (mis)aggregation.

1. Introduction

Differences in endowments play a central role in international trade theory. According to both the Heckscher-Ohlin and the monopolistic competition models (Helpman 1981, Helpman and Krugman 1995), the share of net or inter-industry trade in total trade is expected to be larger the greater the differences in relative factor endowments between countries. Monopolistic competition models also involve intra-industry trade (IIT), which is generally assumed to be horizontal (HIIT) in nature – i.e. to involve the exchange of differentiated varieties of the same good, produced using a common increasing returns to scale technology – and therefore to involve no net exchange of factor services. This can be distinguished from matched exchanges of vertically differentiated commodities - vertical intra-industry trade (VIIT) - which involves the exchange of different qualities of the same good, produced using different technologies. Explanations of VIIT involve differences in endowments (between countries) and in factor requirements within each industry (e.g. Falvey, 1981; Falvey and Kierzkowski, 1987; and Gullstrand, 2000).

While most of the theory has focussed on HIIT, empirical studies reveal that matched exchanges of vertically differentiated commodities are the dominant type of trade in most developed countries[1], and that VIIT embodies net exchanges of factor services[2]. These studies have tended to presume that, like net trade (NT), there is a positive monotonic relationship between the extent of endowment differences between countries and the share of VIIT in total bilateral trade. But existing trade models do not allow us to draw clear inferences about this, and we show below that the data suggest a more complex relationship between VIIT and differences in endowments.

Responding to this evidence and to the need to clarify both the relationship between VIIT and HIIT and that between VIIT and net trade, we develop a framework that links the Chamberlain-Heckscher-Ohlin (C-H-O) model with the specific factors model. In doing this we follow a similar line to Krueger (1977) and Deardorff (1984), who combine elements from the Heckscher-Ohlin and specific factor models[3]. The result is a modelling framework that allows for the simultaneous existence of HIIT, VIIT and NT, from which we are able to draw some

[1] E.g. Greenaway *et al.* (1994, 1995), Durkin and Krygier (2000), Blanes and Martin (2000) and Fukao *et al.* (2003).

[2] Using factor content analysis, Cabral, Falvey and Milner (2005) show that the net exchanges of factors embodied in VIIT are as intense as those embodied in the same volume of net trade and are consistent with the factor abundance predicted by the endowments.

testable hypotheses about the relation between endowment differences and the shares of HIIT, VIIT and NT in total bilateral trade. In particular, we argue that the relation between VIIT and inter-country endowment differences is not necessarily monotonic, with the share of VIIT increasing with small differences in endowments but decreasing for wider differences in endowments. To test these hypotheses we follow the method used by Greenaway *et al.* (1994; 1995), disentangling VIIT from HIIT, and estimating separate regressions for the determinants of each of these types of trade flows. We also follow the suggestion of Hummels and Levinsohn (1995) and use direct measures of the endowments as country determinants.

The remainder of the paper is organised as follows. Section 2 presents the relationship of the present work with the existing empirical literature. Section 3 presents some descriptive evidence on the patterns of EU trade and endowment differences with its trading partners. Section 4 sets up the model and extracts the hypotheses to be tested empirically. Section 5 outlines our empirical strategy and section 6 presents the results of the econometric testing. The conclusions of the study are set out in section 7.

2. Relationship to the Existing Empirical Literature

Early empirical studies of the determinants of IIT tended to test the C-H-O model of IIT on the presumption that IIT was predominantly two-way trade in horizontally differentiated goods which did not involve significant net exchanges of factor services. This was consistent with the evidence that IIT dominated North-North trade, while net trade or inter-industry trade which did embody important exchanges of factor services dominated North-South trade. Using total IIT most of these studies found negative signs for the difference in GDP per capita variable (used as a proxy for differences in endowments), which was seen as confirmation of the C-H-O model. But Hummels and Lehvison (1995) cast doubt on the robustness of these results. Using direct measures of endowments (rather than GDP per capita) they obtain results contrary to the C-H-O predictions. One explanatory factor is that the early empirical work on the determinants of IIT did not separate vertical from horizontal matched exchanges, and more recent work reveals that matched trade flows may include net exchanges of factor services similar to those included in net trade, when these consist of exchanges of vertically differentiated commodities (Cabral, Falvey and Milner, 2006).

[3] In a similar fashion Davis (1995) adds Ricardian elements (technology differences) to the HO model to explain HIIT under constant returns to scale technologies and perfectly competitive markets.

The work of Abd-el-Raman (1991) and Greenaway et al. (1994) established a method to separate vertical from horizontal IIT, and provided evidence that matched exchanges of vertically differentiated commodities are the dominant form of IIT, even in the trade between developed countries[4]. Most of the studies that disentangle vertical from horizontal IIT hypothesize a positive relationship between endowment differences and VIIT and a negative relationship between HIIT and endowment differences. The studies that run separate regressions for horizontal and vertical IIT failed to confirm these expectations for VIIT. Rather they reveal contradictory results. Greenaway et al. (1994, 1999)[5], Blanes and Martin (2000) and Fukao et al. (2003) obtained negative signs for the differences in GDP per capita when used to explain VIIT, while Gullstrand (1999), Martin-Montaner and Orts Rios (2002), Durkin and Krygier (2000), and Crespo and Fontoura (2001) found positive signs on the same variable. The use of direct measures of factors, as suggested by Hummels and Levinsohn (1995), has been applied in only a few of the empirical studies that separate vertical from horizontal IIT. Martin-Montaner and Orts Rios (2002) found a positive and significant relationship between VIIT and differences in endowments of human capital and capital per worker[6]. Crespo and Fontoura (2001) find, however, a negative sign for the case of differences in human capital[7].

Here we argue that the approach followed by the earlier empirical studies was mistaken in expecting VIIT to behave like HIIT. We also argue that the hypothesis considered in recent empirical studies, namely that the share of VIIT flows in total trade is related to differences in endowments in the same way as NT, cannot necessarily be inferred from a general equilibrium framework that allows for simultaneous HIIT, VIIT and NT flows and is not reflected in the data.

[4]The Greenaway et al. (1994) study of the UK trade in 1988 report that about 70% of the matched trade should be classified as vertical intra-industry trade. Similar evidence was presented by Abd-el Raman (1991), for French trade in 1985-87, and by Durkin and Krygier (1997) for US trade with the OECD countries in 1989 to 1992. In our calculations we found that VIIT accounts for 78% of the bilateral IIT between the UK and the OECD countries in 1996.

[5]The Greenaway et al. (1994) results show a negative sign for the variable differences in GDP per capita both for vertical and horizontal IIT. Greenaway et al. (1999) also found negative signs for differences in per capita income, but obtained a positive sign for differences in the capital stock per worker. This corresponded to what they expected for VIIT, but not for HIIT, for which the same sign is reported.

[6] Note that their study is concerned only with the trade of Spain with the OECD countries. Most of these countries have higher GDP per capita than Spain. This may influence their result, which is interesting and valid but probably refers only to one type and not to the whole of VIIT flows. See section 6.

[7] Fukao et al. (2003) also consider differences in human capital, but obtain insignificant results.

3. Some Evidence on Endowment Differences and Trade Patterns

We follow Abd-el-Rahman (1991) and Greenaway *et al.* (1994) and use the unit values of exports and imports to determine if matched exchanges of a particular sector are considered as VIIT or HIIT. For each product the ratio $UV_{ij}^{X} / UV_{ij}^{M}$, where UV_{ij}^{X} and UV_{ij}^{M} are the unit value of exports and imports (the price per tonne) of the sub-sector j which is included in industry i, determines the quality of the exports relative to the imports. For values of this ratio in the interval:

$$1-\alpha \leq \frac{UV_{ij}^{X}}{UV_{ij}^{M}} \leq 1+\alpha$$

the matched trade of the sub-sector i is considered as HIIT, while for values below or above it is considered VIIT[8]. The Grubel and Lloyd (GL) index of IIT for each type of trade flow is given by:

$$GL^{*} = \frac{\sum_{i}(X_{ic}^{*} + M_{ic}^{*}) - \sum_{i}| X_{ic}^{*} - M_{ic}^{*} |}{\sum_{i}(X_{ic}^{*} + M_{ic}^{*})}$$

where the X* and M* represent the exports and imports of each commodity that are considered to be of type * (i.e. are considered to be horizontally or vertically differentiated).

Applying this methodology to the EU member countries' trade with 51 major trading partners in 2002, Figure 1(a) shows an inverse relationship between VIIT and differences in GDP per worker overall, although with some tendency for the share of VIIT to rise for small endowment differences[9]. This is certainly not in line with the traditional expectation of a positive relationship. VIIT tends, however, to be higher the more developed (level of GDP per worker) is the partner country of the EU (see Figure 1(b)). This does correspond with other findings that VIIT is predominantly North-North in nature.[10] Figures 1(c) and 1(d) show the relation between differences in GDP per worker and HIIT and NT. The clear picture that emerges is that the share of HIIT decreases with differences in GDP per worker and that of NT increases with endowment differences, as the CHO model predicts. Also, when one plots the level of GDP per worker (or

[8] When the price per unit (tonne) of the exports exceeds that of the imports by a significant margin the proportion given by the parameter (α) will determine that VIIT is high quality, when it is below the interval that the vertical IIT is low quality. There is a degree of arbitrariness in the selection of the dispersion criterion which may give rise to concerns (see for example Nielsen and Luthje, 2002). The methodology does allow a comprehensive measurement of trade types, however.

[9] Graphics for GDP per capita and capital per worker were also calculated. The plotted results are very similar for the relation of the share of VIIT in total trade with each of these three variables (GDP per worker, GDP per capita or Capital per worker).

per capita) the proportion of NT in total trade tends to be smaller the larger is GDP per worker, while the proportion of HIIT tends to be larger the larger is the GDP per worker of the trading partner of the EU. This corresponds well with the established idea that (HIIT) takes place in North-North trade, while inter-industry trade dominates North-South trade.

It is evident from these Figures that VIIT is different to both HIIT and NT in terms of its relationship to endowment differences for this sample of countries. This is even clearer when we separate the countries in our sample into high income countries (Figure 1(e)) and middle and low income countries (Figure 1(f))[11]. The first group includes countries with similar or higher per capita incomes than the EU average, while the second group includes countries that are all below the EU average. The plots indicate a positive relationship between VIIT and differences in endowments for the first group of countries, and a negative relationship for the latter. For large samples of countries, including those with both larger and smaller endowments, we should not therefore expect to generate a monotonic relationship between differences in endowments and VIIT.

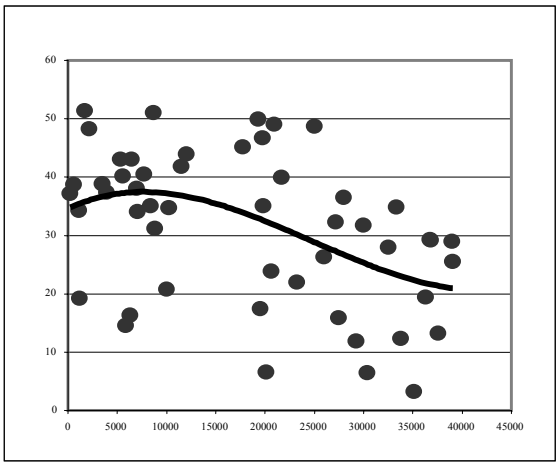
If one separates the countries so that only countries above (below) the average are included, the results expressed in differences became very similar to those expressed in levels, since the larger (smaller) the GDP per worker (or per capita) the larger will be the difference in GDP per worker. When we are dealing only with countries with a higher (lower) level of development most of the VIIT will be of the type where the reference country exports (imports) the lower quality varieties and imports (exports) the higher quality. In such samples one is studying only one type of vertical IIT and its relation with the level of endowments or income per capita. In this sense, the evidence obtained in those studies (e.g. Martin-Montaner and Orts Rios, 2002; Gabrisch and Segana, 2002), should be seen as modelling of the determinants of a type of VIIT, not of VIIT in general.

[10] Although it is worth noting that the *share* of VIIT is much larger in the trade between the EU and less developed countries in particular.

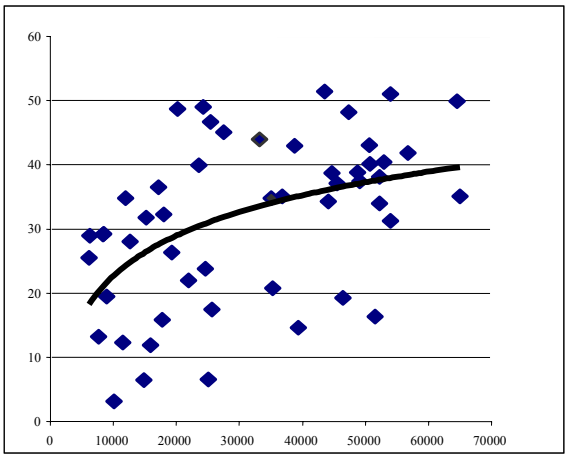
[11] Countries with more than $US 20,000 of per capita income in 2002 were considered to be High Income and include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Singapore, Sweden, Switzerland, UK, USA. Those with income per capita less than $US 20,000 were included in Middle Income and Developing – namely Argentina, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Czech Rep., Estonia, Greece, Hungary, India, Indonesia, Israel, Malaysia, Mexico, Peru, Philippines, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain. Sri Lanka, Thailand, Turkey, Venezuela.

Figure 1: Patterns of EU bilateral trade and endowment differences

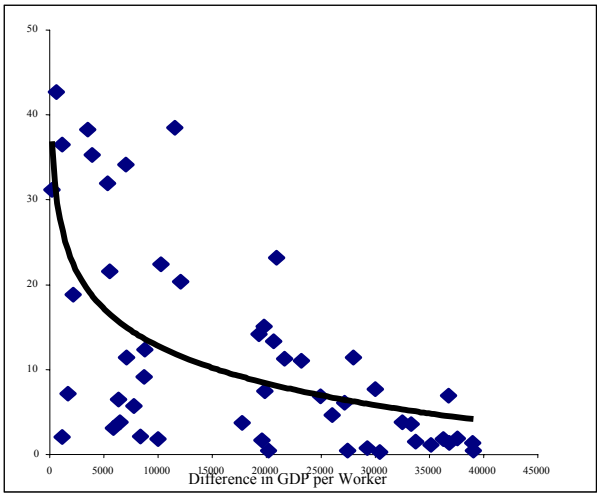
a. - Vertical IIT and Differences in GDP*



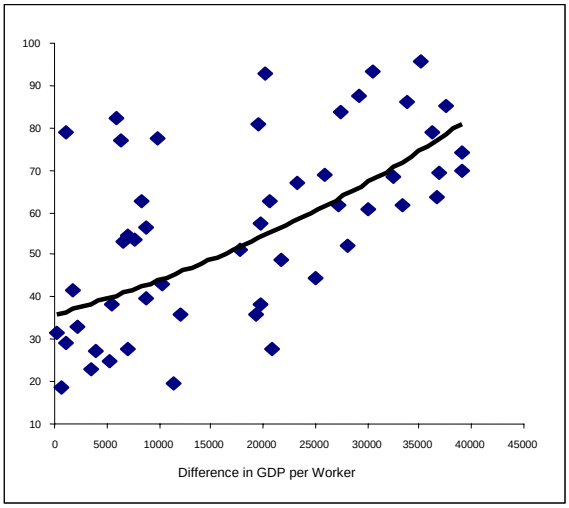
b. - Vertical IIT and Level of GDP**



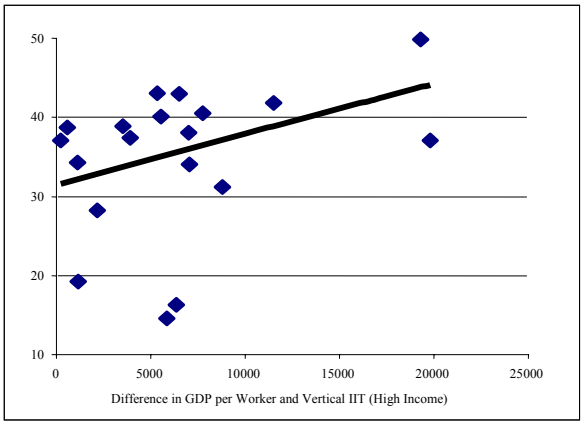
c. - Horizontal IIT and Differences in GDP*



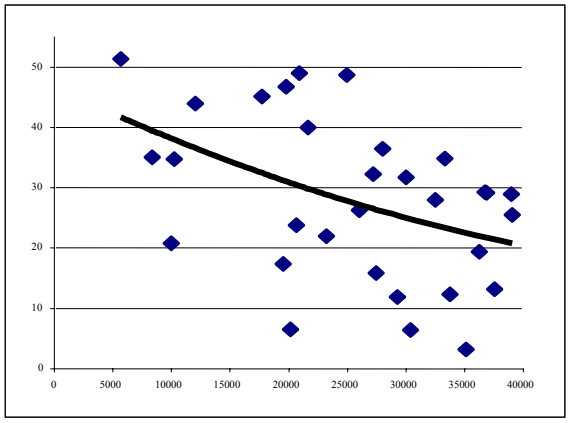
d. - Net Trade and Differences in GDP*



e. - High Income Developed Countries
Vertical IIT and Differences in GDP*



f. - Middle Income and Developing Countries
Vertical IIT and Differences in GDP*



* Each point represents a country, giving the share of each type of trade in total trade (vertical axis) and the difference between the EU average GDP per worker and the GDP per worker of each of the 51 countries considered (horizontal axis).
** In (b) the horizontal axis presents the level of GDP per worker of each of the 51 countries.

4. A General Equilibrium Framework

In this section we lay out a simple general equilibrium model that features the simultaneous presence of HIIT, VIIT and NT, in order to illustrate their interactions and to explore their links with factor endowments. We do this by combining models that are familiar from the literature - the CHO model (Helpman, 1981; Helpman and Krugman, 1985), which explains HIIT and NT in a general equilibrium setting; the partial equilibrium VIIT model (Falvey, 1981); and a hybrid Heckscher-Ohlin-Specific-Factors model introduced by Krueger (1977) and developed by Deardorff (1984). In short, we model HIIT as the exchange of high quality, capital-intensive, *differentiated* products in a monopolistically competitive market; VIIT as the exchange of these products for a *basic* lower quality, labour-intensive, homogeneous manufactured product; and NT as the exchange of either of these products for a homogeneous *agricultural* output which is produced using land and labour.

Assumptions

We consider two sectors. Agriculture employs land and labour to produce a homogeneous product (denoted by A) using a constant returns to scale technology. Manufacturing uses capital and labour, and produces two types of output, a homogeneous, basic product (denoted by B), and differentiated higher quality varieties (denoted by D)[12]. The basic product is produced under a constant returns to scale technology by competitive firms. Production of the differentiated varieties is best viewed as taking place in two steps. First, capital and labour are combined to produce a (hypothetical) homogeneous input (denoted by I) using a constant returns to scale technology that is more capital intensive than that used in the basic output. This input is then be used to produce the differentiated varieties, via a standard Krugman (1979) technology where production of each variety involves a fixed cost and a constant marginal cost, both expressed in terms of the hypothetical input. This leads to each variety being produced by a single firm in a monopolistically competitive setting. For convenience, units of differentiated output are chosen so that the marginal cost of producing one unit of differentiated output is one unit of the hypothetical input. Thus production of x units of a differentiated variety requires

$$x_I = f + x$$

units of hypothetical input, where $f > 0$ denotes the fixed cost.

[12] The underlying idea is that in manufacturing industries a relatively small number of large firms compete with a fringe of a large number of small firms. The former in many cases are companies that produce differentiated goods

All goods are traded internationally, and all countries have access to the same production technologies[13]. As in most trade models, preferences are assumed to be identical across countries. We follow Krugman (1979) in assuming that there is *love for variety* in the demand for the differentiated varieties. We further suppose that the utility of the representative consumer is a Cobb-Douglas function of consumption of the agricultural good, the basic manufactured product and a composite of the differentiated varieties:

$$U = c_A^{\alpha} c_B^{\beta} u_D^{\delta}$$

where $u_D = \left[\sum_{j=1}^{n} c_j^{\rho} \right]^{\frac{1}{\rho}}$, $0 < \rho < 1$ is the differentiated variety composite. Profit maximisation implies that the price of a typical variety (p_D) is a markup on its marginal cost

$$p_D = \frac{\varepsilon}{\varepsilon - 1} p_I$$

where p_I is the cost of a unit of the hypothetical input. Free entry implies zero profits in equilibrium, which leads to an optimum firm size of

$$x = f[\varepsilon - 1]$$

Since preferences are identical and symmetric, and the same amount of each variety is produced in equilibrium, their prices must be identical. This implies, given a common markup, that the unit price of the hypothetical input must also be identical across countries. Trade will equalize the prices of the basic manufactured output and the agricultural good (which will be taken as the numeraire). A country producing all three types of output in equilibrium will have competitive profit conditions

$$(p_A \equiv) 1 = c_A(w, v)$$

$$p_B = c_B(w, r)$$

$$p_I = c_I(w, r)$$

where $c_j(.,.)$ is the unit cost function for output $j = A, B, I$, which depend only on factor prices since their respective technologies are all CRS. Two countries that produce all three outputs will

(with strong brand identification) under increasing returns to scale, while the latter are small firms that compete on a cost basis.

[13] As noted earlier, Davis (1995) explains IIT by extending the HO model to include cross-country technology differences in the different goods produced by a multi-product industry. His objective is to explain IIT in goods produced with similar factor intensities, and thus involving negligible net embodied-factor trade, which are the characteristics of HIIT. Since the evidence suggests that VIIT does involve net embodied-factor trade, an assumption of technology differences across goods of differing quality seems appropriate here.

have the same factor prices and therefore, given common technologies, produce using the same input combinations. Their mix of outputs will depend on their factor endowments, however.

Diagrammatic representation

The patterns of specialization and trade in this model can be represented using the technique employed by Deardorff (1984, p.735). The upper panel in Figure 2 represents the tangency of a unit cost line (whose slope represents the relative costs of capital and labour in the non-specialised equilibrium) with the unit value isoquants for the two manufacturing outputs (B and I). This tangency determines the equilibrium capital-labour ratios employed in this industry when both outputs are produced (k_I, k_B). Suppose the country's capital stock is given by K_E. Then its equilibrium output mix in the manufacturing sector depends on that sector's employment of labour. If this is less than L_M^1, then full employment requires that this country's manufacturing specialises in the differentiated varieties, with the capital labour ratio employed in producing the hypothetical input exceeding k_I, and the factor returns corresponding to their value marginal products in hypothetical input production. Similarly, if the labour employment in manufacturing exceeds L_M^2, the sector specialises in the base product which is produced using a capital labour ratio less than k_B. In between both manufacturing outputs are produced, and increased employment is absorbed by readjustments of the output mix towards the more labour intensive basic product at constant factor prices.

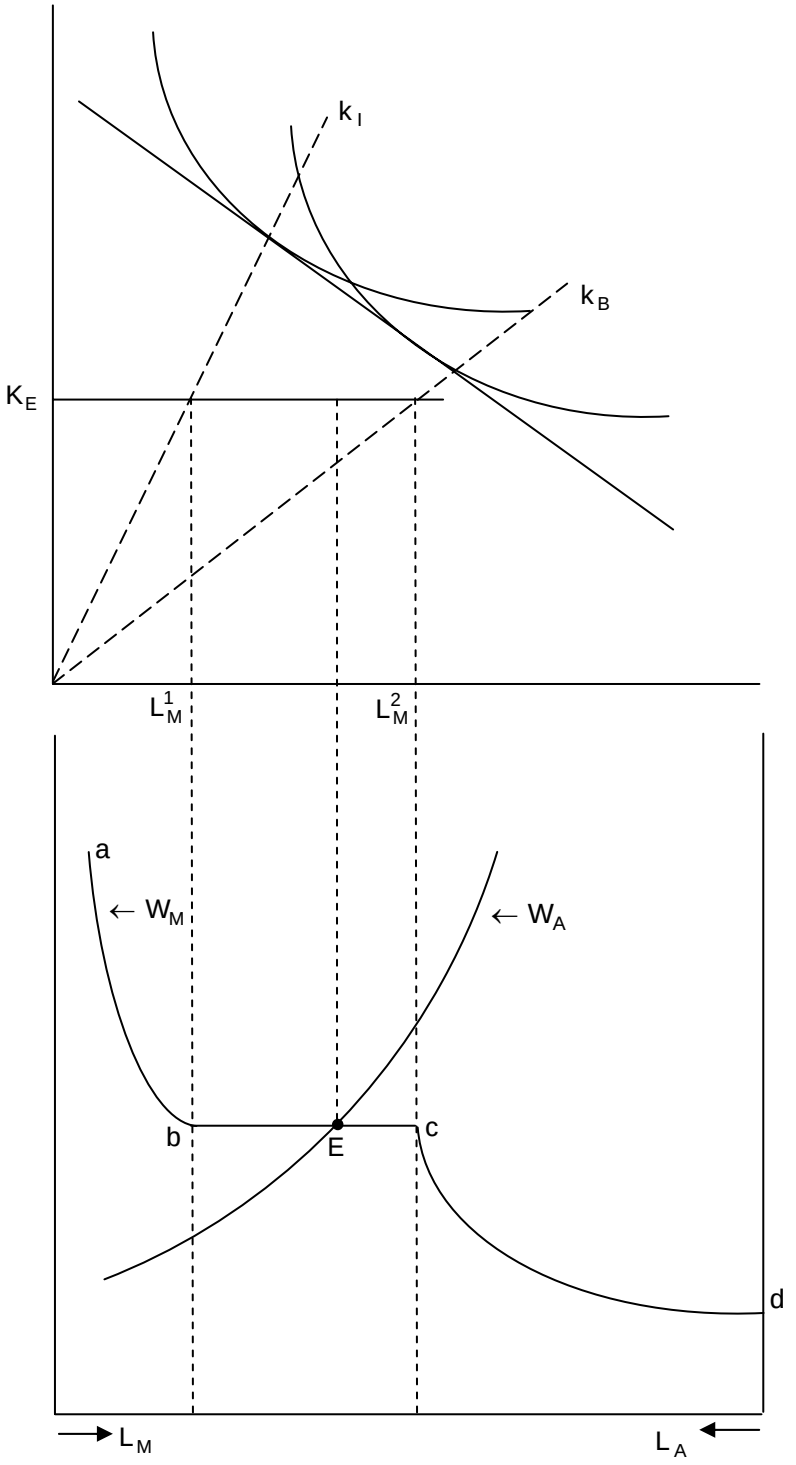
The lower panel in Figure 2 represents the labour market equilibrium diagram familiar from the specific factors model. The value of the marginal product of labour in the Agricultural sector depends on the land endowment and the quantity of labour employed in Agriculture, as shown by the W_A schedule measured relative to the right-hand axis. The corresponding schedule for manufacturing (W_M) is downward sloping in the employment ranges where the sector is specialised in one of the two products, but is horizontal (at the FPE wage rate) in the range where this sector is non-specialised. The manufacturing employments over which this horizontal section occurs clearly depend on the size of the capital endowment.

Our objective is to explore how the different factor endowments of countries are reflected in their trade patterns in this equilibrium. For purposes of comparison we begin with a "reference" country that is non-specialised in the trading equilibrium and has labour market equilibrium as

shown by point E in Figure 2. This country is constructed so that its endowment is such that its outputs match its demands for both the agricultural and the basic product, implying that the only trade that it undertakes is intra-industry trade in differentiated manufacturing products[14]. From this reference point we can then see how their endowments determine other countries' trading patterns in this equilibrium. The model also provides a natural notion of "small" and "large" endowment differences (relative to the reference country) depending on whether the comparator is inside or outside the FPE cone. To reduce the number of potential comparisons, we assume all countries have the same labour endowment, so that we effectively consider differences in per capita endowments. This involves no loss of generality, however, since the output of the agricultural good and the basic manufactured good and the number of differentiated varieties are linearly homogeneous in total factor inputs. Endowment differences will affect the trade pattern through both supplies and, via their effects on per capita income, demands. Often these effects reinforce each other, but where they clash we will generally assume the output effect dominates[15]. Since this is, of necessity, rather a taxonomic exercise we summarise the results in Table 1.

[14] No such country need actually exist.
[15] Reflecting the magnification effect of endowments changes on outputs as exemplified in the Rybczynski Theorem.

Figure 2: Factor Allocations in the Trading Equilibrium



Differences in land endowments

Trade patterns: We begin by considering countries that differ from the reference country only in their land endowments. A slightly smaller land endowment would leave the intersection between the two "wage schedules" somewhere in the range Ec. Output of the agricultural good would be lower and it will be imported. Output of differentiated products (specifically the number of differentiated products produced) will also be lower, while output of the basic manufactured good will be higher. This suggests exports of the basic manufactured good in exchange for imports of differentiated manufactured products and agricultural output. A significantly smaller land endowment would mean an equilibrium on the cd section of the manufacturing wage schedule. Such a country would only produce agricultural and basic manufactured products, but with basic manufactured output much higher and agricultural output much lower than in the reference country. The former will be imported and the latter exported as a consequence. Alternatively, a country with a land endowment slightly larger than that of the reference country (and therefore on Eb), will produce more agricultural goods and differentiated varieties and less of the basic manufactured product. Its trade pattern will show exports of agriculture and differentiated varieties, and imports of the basic manufactured product. For a relatively land abundant country, the labour market equilibrium will lie on section ab of the manufacturing wage schedule. Production is specialized in differentiated varieties and agricultural goods, but output of the former is lower than at point b (where output of differentiated varieties is greatest). The trade pattern involves imports of basic manufactures and exports of the agricultural product and differentiated varieties, with the latter declining as the land endowment gets larger.

Trade Shares: In this setting there will exist some HIIT between any two countries, as long as there is some production of the differentiated varieties in both. The share of HIIT is maximized in the reference country, however, where all trade is HIIT. Since endowment differences generate other forms of trade, the share of HIIT must fall. A larger land endowment implies: (a) increased agricultural exports and hence an increased share of NT; and (b) increased imports of basic manufactures which will involve increased VIIT until production of the differentiated varieties begins to fall, when VIIT will also begin to decline. A smaller land endowment implies (a) increased agricultural imports and hence an increased share of NT; and (b) increased exports of basic manufactures and increased imports of differentiated varieties implying increased VIIT. But once production of differentiated varieties ceases, there is no HIIT, and imports of differentiated varieties begin to fall as per capita income declines, implying reduced VIIT.

Differences in capital endowments

Trade Pattern: A larger (smaller) capital endowment shifts the downward sloping sections of the manufacturing wage schedule to the right (left), with a corresponding shift of the horizontal segment (at the same wage level). A slightly larger (smaller) capital stock than the reference country (with the same land and labour endowment), leads to no change in agricultural output, as long as the equilibrium remains on the horizontal section of the manufacturing wage schedule, and a switch in the composition of manufactured output away from basic (differentiated) towards differentiated (basic) products. There are net imports (exports) of agricultural goods because per capita income has risen (fallen), supplemented by the export (import) of high quality differentiated varieties in exchange for basic product imports (exports).

Larger differences in capital endowments shift the labour market equilibrium to one of the downward sections of the manufacturing wage schedule. Thus if a country has a much larger capital endowment than the reference country, its manufacturing sector will specialize in differentiated varieties, and its output of agricultural goods will be less than the reference. All basic manufactures consumed are imported, as are some agricultural products. Differentiated varieties are exported. Alternatively, if a country's capital endowment is much smaller than that of the reference country, its manufacturing sector will specialize in the basic product. Its agricultural output will be higher than in the reference country and its demand (per capita) will be smaller since its income per capita has fallen. The trading outcome is the export of agricultural output and basic manufactures for differentiated manufactured imports.

Trade Shares: The share of HIIT falls relative to the reference country for the same reason as above. An increasing capital endowment leads to (a) increasing agricultural imports and hence growing NT; and (b) increasing exports of differentiated varieties and imports of basic manufactures, hence increasing VIIT. All basic manufactures consumed are imported once the equilibrium is on the (transposed) ab range of the manufacturing wage schedule. A falling capital endowment leads to (a) increasing agricultural exports implying growing NT; and (b) increasing exports of basic products in exchange for differentiated varieties, implying increased VIIT. However, once the capital endowment difference is sufficiently large, production of differentiated varieties ceases and there is no HIIT. Further decreases in the capital endowment reduce basic manufactures output and VIIT begins to decline.

Table 1: Endowment Differences, Production and Trade Patterns

Endowment Type	**Endowment Difference (Direction & Size[1])**	**Production Pattern**	**Patterns of Trade**		**Shares of Trade (using Reference Country as base)**		
			VIIT	**NT**	**HIIT**	**VIIT**	**NT**
Land	Large Increase	A and D	Exp D Imp B	Exp A Imp B	Falling	Rising then Falling	Rising
	Small Increase	A, B and D	Exp D Imp B	Exp A Imp B	Falling	Rising	Rising
	Small Decrease	A, B and D	Exp B Imp D	Exp B Imp A	Falling	Rising	Rising
	Large Decrease	A and B	Exp B Imp D	Exp B Imp A	None	Rising then Falling	Rising
Capital	Large Increase	A and D	Exp D Imp B	Exp D Imp A	Falling	Rising	Rising
	Small Increase	A, B and D	Exp D Imp B	Exp D Imp A	Falling	Rising	Rising
	Small Decrease	A, B and D	Exp B Imp D	Exp A Imp B	Falling	Rising	Rising
	Large Decrease	A and B	Exp B Imp D	Exp A Imp D	None	Falling	Rising

Notes: 1. The endowment difference is defined as small relative to the reference country if it remains within the cone of diversification, and large otherwise.

Testable hypotheses

The modeling framework allows for the simultaneous existence of HIIT, VIIT, and NT between a pair of countries, and allows some predictions about how the different types of trade change with endowment differences.

HIIT with the reference country will decrease continuously with the widening of the endowment difference with its trading partner (until it disappears completely). The model predicts this for the widening of endowment differences with both more and less endowed (developed) trading partners. We should therefore expect a negative sign on absolute endowment differences in a model of the determinants of the share of HIIT irrespective of the composition of the sample of trading partners.

VIIT is predicted to increase for both small increases and decreases in endowments (both capital and land) relative to the reference country. It is also expected to increase initially and then decline for large increases or decreases in land endowment differences. In the case of capital endowments, however, there is an asymmetry in the impact of (large) increases and decreases in

endowments; the share of VIIT rising for large increases and falling for large decreases. Thus, while we can expect a non-linear relationship between VIIT and absolute land endowment differentials (an 'n-shaped' relationship), where the sample of trading partners includes countries with both similar and significantly different capital endowments (both more and less developed), there is ambiguity. For a sample of trading partners with larger endowments than the reference country we would expect a positive relationship between the share of VIIT and the capital endowment differential. For a sample with only smaller endowments than the reference country we would expect, in general, an 'n-shaped' relationship, or a negative relationship if only countries with significantly smaller endowments are included in the sample.

The share of NT in total bilateral trade increases for small and large increases in absolute endowment differentials (capital and land). For those increases in endowment differentials where the share of VIIT also increases there is strictly ambiguity about how the ratio of VIIT to NT changes. For the cases where the share of VIIT falls with endowment differential increases we expect the ratio of VIIT to NT to fall, namely for large decreases in capital endowments relative to the reference country and sufficiently large increases or decreases in land endowments. The sign on the absolute endowment differential term in a regression of the determinants of the ratio of VIIT to NT is strictly ambiguous therefore, unless we constrain the characteristics of the sample of trading partners. We have, for instance, a stronger expectation of a negative sign in a sample of trading partners with significantly smaller endowments than the reference country.

A summary of the expected, estimated signs on the endowment differential in regression models of the determinants of the various trade share variables discussed above are set out in Table 2.

Table 2: Summary of Expected Signs on Endowment Differential - Trade Share Relationship

Dependent Variable	In Trade of Reference Country with					
	Full Sample of Trading Partners		Similar/High Income Countries		Middle Income and Developing Countries	
	Endowment differential:		Endowment differential:		Endowment differential:	
	capital	land	capital	land	capital	land
HIIT	*negative*	*negative*	*negative*	*negative*	*negative*	*negative*
VIIT	*?*	*n-shaped*	*positive*	*n-shaped*	*negative*	*n-shaped*
V/NT	*?*	*neg. ?*	*?*	*neg. ?*	*negative*	*neg. ?*

5. Empirical Modelling and Strategy

Specification, data and independent variables

The model presented here seeks to explain the variation of different types of trade flows in the bilateral trade of the European Union (EU) countries with each of its major trading partners[16] in each industry "i" for four different periods of time[17]. The regressions consider different dependent variables and explanatory variables as listed in Table 3. The explanatory variables reflect (a) differences in endowments measured in alternative ways - differences in GDP per capita, capital per worker, human capital, or land per worker; and (b) control variables commonly used in studies of determinants of IIT, such as size of the economy, distance, income level, or membership of the EU.

[16] Specifically, the trade flows considered are those between the trade partner and the EU in aggregate. Where the trade partner is a member of the EU, the trade flow considered is that with the remainder of the EU. The 51 countries considered are the major trading partners of the EU countries for which data was available and are listed in footnote 11. This included the 25 largest partners of the EU15 in 2002, and 41 of the 44 major trading partners. Among the 50 countries with the largest volume of trade with the EU15, only 8 were excluded (for lack of endowment data) - Taiwan, Saudi Arabia, Algeria, Morocco, Tunisia, Iran, Libya and Nigeria. On the other hand Venezuela, New Zealand, Colombia and Costa Rica, are included although they are not among the 60 bigger trading partners.

[17] We used data following the NACE classification at four digits (248 different sectors). To determine VIIT and HIIT of each of these 248 sectors we used compatible commodity data disaggregated into more than 10,000 products. The years considered were 1995, 1997, 1999 and 2002. VIIT and HIIT were calculated using alternatively the values of 15% and 25% to calculate the interval of matched trade that is considered HIIT. We only present results for the first case (α=0.15) since these do not differ in any significant way when a wider interval was considered. All observations for which the sum of exports and imports was less than $US100,000 were excluded. The trade excluded in this way was less than 1% of the total trade.

The general form of the regressions is:

$$T_{ict} = \text{Constant} + \beta \text{Endowment-Differences}_{ct} + \gamma \text{Other}_{ct}$$

where the trade share dependent variable (T) is either:

HIIT = share of HIIT in gross trade, or

VIIT = share of VIIT in gross trade, or

V/NT = ratio of VIIT to NT

We present results for regressions using Ordinary Least Squares with robust standard errors[18].

Table 3: Independent Variables

Variable Description	**Source**
GDP at current prices	PWT 6.1
GDP per capita at current prices	PWT 6.1
GDP per worker constant prices (base 1996)	PWT 6.1
Difference GDP per capita current prices	PWT 6.1
Difference GDP per worker constant prices (base 1996)	PWT 6.1
Dummy with the value 1 for the European Union countries	
Average distance of trading partner capital to Paris and Berlin	
Land/Labour ratio	NBER – Trefler
Capital/Labour ratio	PWT 5.6
Proportion of population with Post Secondary Education	Barro and Lee
Difference in GDP per capita current prices	PWT 6.1
Difference in GDP per worker constant prices (base 1996)	PWT 6.1
Difference in Capital per Worker	PWT 5.6
Difference in Proportion of population with Post. Sec. Ed.	Barro and Lee
Difference in Land/Labour ratio	NBER – Trefler

Notes: (a) We also considered variables at constant prices (base 1996). The results were very similar to those obtained with these variables expressed in current prices. A variable expressing total Population was also used as an alternative to GDP. (b) We consider the proportion of the population above 25 years with complete and incomplete post secondary education. Alternatively, we also consider only the proportion of population with complete post secondary education and plus this added to the proportion of the population with secondary education. Several other variables were used to express Labour Qualifications (and their differences), namely the number school years, and the proportion with secondary education.

Empirical strategy

Regressions are reported for the full sample of countries, because in some instances we have hypothesised that the effect of endowment differences is not sensitive to whether the EU's trading partner has larger or smaller endowments, and whether small or large differences are involved. In other instances it is. We address this issue in two different ways. First, we divide the observations into two different sub-samples; one including the high income countries that have endowments that are not dissimilar to the European Union average, and another sub-sample that includes the middle income and developing countries, which have lower and wider differences in their endowments relative to those of the EU. The alternative way of addressing

[18] We explored also a Logistic and Probit specification. The results are qualitatively similar to those from the OLS models and are not reported here, but are available from the authors.

this issue is to decompose VIIT into that where the EU (trade partner) is the importer (exporter) of high quality varieties and that where the EU (trade partner) is the importer (exporter) of low quality varieties[19]. We expect, from our model, that countries with higher endowments than the EU will be exporters of high quality varieties and those with lower endowments to be exporters of low quality varieties.

6. Regression Results

Horizontal IIT

As outlined earlier, our expectations about the sign on the endowment differences – HIIT relationship are unambiguous and insensitive to the selection of the sample of trading partners. A negative sign on absolute endowment differences (capital and land) is expected in a regression of the determinants of the share of horizontal IIT for the full sample of the EU's trading partners. The results reported in Table 4, estimations 1 and 2 fully confirm the expected relationship; the per capita GDP differential (eq. 2) or capital per worker differential (eq.1), and land per worker differential (eq. 1 and 2) variables are all negative and significant. As found in other studies of the determinants of HIIT we find strong support for a similarity thesis, namely that the share of horizontal IIT in gross trade increases, other things constant, as endowment differentials between countries are reduced. The signs on the other control variables are also as expected.

For completeness we also check that the results in Table 4 are insensitive to sample selection. In Table 5 we report the determinants of the share of HIIT estimated separately for the EU's bilateral trade with high income trading partners (5a) and for middle income and developing countries (5b). Again negative signs with significance are found on all the endowment differential variables in equations 1 and 2 for both sub-samples of trading partners.

[19] A case where the value per tonne of its exports to the EU is greater than 15% of that of its imports from the EU of the same product.

Table 4: Determinants of the Share of Horizontal and Vertical IIT (Full Sample of Countries)

	Horizontal IIT		Vertical IIT)	
Equation:	**1**	**2**	**3**	**4**
GDP	0.101 (3.66)***	0.156 (5.71)***	0.041 (1.21)	0.072 (1.77)*
EU	0.806 (9.53)***	0.542 (7.21)***	-0.38 (4.76)***	-0.32 (-2.85)***
Distance	-0.601 (-8.02)***	-0.652 (-9.34)***	-0.256 (-4.13)***	-1.26 (-10.92)***
Capital per worker	0.183 (8.45)***		0.197 (6.06)***	
Per capita GDP		0.251 (3.12)***		0.245 (2.62)***
Per capita GDP differential		-0.594 (-10.54)***		-0.538 (-6.21)***
Capital per worker differential	-0.530 (-3.73)***		-0.532 (-4.25)***	
Land per worker differential	-0.723 (-3.41)***	-0.683 (-2.98)***	-0.236 (-5.23)***	-0.211 (-4.73)***
F-statistic	478.18	471.77	191.64	354.62
Adjusted R-squared	0.0816	0.0817	0.0347	0.0625
Observations	10664	10664	10664	10664

T-statistics in brackets. Level of significance of 10% (*), 5%(**) and 1% (***)

Vertical IIT

The expectations on the vertical IIT – endowments relationship differ according to the selection of trading partners and the type of endowment (see Table 3). In the regressions for the full sample of countries (Table 4) we find negative (and significant) signs on the per capita GDP differential (eq. 4), the capital per worker differential variable (eq. 3) and the land per worker differential term (eqs. 3 and 4). We expected the relationship to become an inverse one at some point in the case of land differences, but we were unable to capture (in regressions not reported) an 'n-shaped' relationship through the inclusion of a quadratic term. The negative sign on the land and the capital endowment differential terms may reflect the fact that the full sample includes a relatively large proportion of countries with significantly smaller endowments (i.e. where the differentials are large).

The unambiguous prediction of the model about the share of vertical IIT relates to the reference country's trade with countries more (less) endowed with capital. We hypothesized a positive sign on the capital endowment differential with high income countries (provided some at least have greater capital endowments), and a negative sign on the capital endowment differential in the case of trade with lower income countries. In Table 5 we find this pattern of signs with significance for the models of VIIT in EU trade with high income countries (5a) and with

middle income and developing countries (5b). In Table 5a we find significant positive signs on both the per capita GDP differential term (eq. 4) and the capital per worker differential variable (eq. 3). While in Table 5b we find a negative, albeit insignificant, sign on the per capita GDP variable, and a significant, negative sign on the capital per worker differential. This is strong support therefore for our modeling framework. Further it is supported by the results in Table 6, where rather than separating the sample of countries, we consider the determinants of VIIT in high and low quality products separately (defined in terms of the exporting trading partner of the EU). Thus, where the trading partner is exporting higher quality (vertically differentiated) products to the EU, the share of this in total bilateral trade is positively related to the capital endowment differential (eq. 1) or per capita GDP differential (eq. 2). By contrast where the trading partner is exporting lower quality varieties to the EU, the share of this VIIT in total bilateral trade is negatively related to capital endowments (eq.3) or per capita GDP differential (eq. 4). This is consistent with higher (lower) income countries increasing (reducing) the share of VIIT in their trade with the EU as the absolute capital endowment differential (with the EU) increases, where we presume that high (low) quality exporters are high (low) income countries.

Non-linear effects of land endowment differences on the share of vertical IIT were hypothesized in section 4; increases in VIIT with small endowment differentials but decreases at some point as endowment differentials increase. For the present sample we consistently find a significant, negative sign on the land endowment differential variable where VIIT is the dependent variable; for the whole sample of countries (eqs. 3 and 4 in Table 4), for the high income countries (eqs. 3 and 4 in Table 5a), for the low income countries (eqs. 3 and 4 in Table 5b) and for where the EU's trade partners are high quality exporters (eqs. 1 and 2 in Table 6) or low quality exporters (eq. 4 in Table 6). This may be because the particular sample of countries does not encompass many small land endowment differentials. Where there are generally large land endowment differentials the modeling framework does predict, controlling for other things, smaller shares of vertical IIT in gross trade.

Table 5: Determinants of the Share of Horizontal and Vertical IIT: High Income and Middle Income and Developing Countries Separated

a: High Income Countries

	HIIT	HIIT	VIIT	VIIT
Equation:	**1**	**2**	**3**	**4**
GDP	0.229 (3.82)***	0.219 (3.67)***	0.150 (2.36)**	0.110 (1.67)*
EU	0.98 (5.90)***	0.63 (3.54)***	0.34 (2.01)**	0.31 (1.78)*
Distance	-0.624 (4.51)***	-1.023 (7.56)***	-1.16 (-5.52)***	-1.22 (-5.63)***
Capital per worker	-0.101 (-0.41)		0.126 (2.12)**	
Per capita GDP		-0.541 (-3.13)***		0.978 (5.35)***
Per capita GDP differential		-0.812 (-4.25)***		0.652 (2.88)***
Capital per worker differential	-0.914 (-3.83)***		0.512 (3.12)***	
Land per worker differential	-0.131 (-2.09)**	-0.168 (-2.91)***	-0.116 (-1.78)*	-0.125 (-2.01)**
F-statistic	139.96	138.58	106.35	121.33
Adjusted R-squared	0.0511	0.0506	0.0392	0.0446
Observations	5157	5157	5157	5157

(a) For the list of countries included see footnote 11.
(b) Vertical and Horizontal Grubel and Lloyd indexes (share of HIIT and of VIIT in total trade).

b: Middle Income and Developing Countries

	HIIT	HIIT	VIIT	VIIT
Equation:	**1**	**2**	**3**	**4**
GDP	0.007 (0.24)	0.037 (1.25)	0.127 (2.92)***	0.189 (4.26)***
EU	0.38 (3.54)***	0.31 (2.92)***	-1.18 (-9.11)***	-1.03 (-8.15)***
Distance	-0.287 (-3.71)***	-0.220 (2.82)***	-0.105 (-10.25)***	-0.115 (11.17)***
Capital per worker	0.132 (3.27)***		0.142 (3.86)***	
Per capita GDP		0.659 (5.34)***		1.12 (7.31)***
Per capita GDP differential		-1.17 (-7.55)***		-0.101 (-0.53)
Capital per worker differential	-0.480 (-3.42)***		-1.56 (-3.23)***	
Land per worker differential	-0.226 (-5.40)***	-0.198 (-4.81)***	-0.875 (-16.32)***	-0.794 (-14.77)***
F-statistic	78.36	102.45	259.28	265.25
Adjusted R-squared	0.0276	0.0359	0.0867	0.0885
Observations	5444	5444	5444	5444

T-statistics in brackets. Level of significance of 10% (*), 5%(**) and 1% (***)

Ratio of vertical IIT to net trade

Where the share of vertical IIT falls with increasing endowment differentials we expect also the ratio of vertical IIT to net trade to fall. We find support for this in the results of the determinants of V/NT in Table 7. The sign on the land per worker differential is negative and significant for all the specifications in this table. Although there is strictly ambiguity about the relative changes in the shares of VIIT and NT as capital endowment differences change (especially for trade with countries with greater incomes or capital endowments), it is the case that VIIT should decrease after some point for endowment differential increases with countries with lower incomes or capital endowments. In which case, in sample of countries with a substantial proportion of lower income countries one would expect there to be an inverse relationship overall between the VIIT/NT ratio and absolute endowment differences. This is what we find for the full sample of trading partners in Table 7. Both the proxies for the capital endowment differential (per capita GDP differential and capital per worker differential) have a negative sign with significance (even after trying to control for large endowment difference effects through the inclusion of dummies).

Table 6: Determinants of the Share of Vertical IIT in High and Low Quality Varieties

	VIIT(HIGH)	VIIT(HIGH)	VIIT(LOW)	VIIT(LOW)
Equation:	**1**	**2**	**3**	**4**
GDP	0.042 (1.73)*	0.048 (1.87)*	0.038 (1.20)	0.062 (1.78)*
EU	0.18 (3.10)***	0.17 (2.61)***	-0.90 (-7.65)***	-0.47 (-5.65)***
Distance	-0.192 (-3.10)***	-0.264 (-4.72)***	-8.17 (-10.81)***	-11.20 (-16.52)***
Capital per worker	0.205 (7.24)***		-0.135 (-6.83)***	
Per capita GDP		0.345 (6.62)***		-0.242 (-3.05)***
Per capita GDP differential		0.263 (2.71)***		-0.347 (-2.98)***
Capital per worker differential	0.432 (3.15)***		-1.348 (-9.77)***	
Land per worker differential	-0.215 (-7.02)***	-0.206 (-6.82)***	-0.032 (-1.22)	-0.046 (-1.73)*
F-statistic	364.51	371.45	194.54	145.45
Adjusted R-squared	0.0651	0.0662	0.0351	0.029
Observations	10664	10664	10664	10664

(a) VIIT(HIGH/LOW) - vertical IIT in which the trading partners are exporting varieties of higher/lower quality than the EU average.
(b) T-statistics in brackets. Level of significance of 10% (*), 5%(**) and 1% (***)

Table 7: Determinants of the Ratio of Vertical IIT to Net Trade (V/NT)

	V/NT	V/NT	V/NT	V/NT
Method:	**OLS(Rse)**	**OLS(Rse)**	**OLS(Rse)**	**OLS(Rse)**
Equation:	**1**	**2**	**3**	**4**
Distance	-14.01 (-21.2)***	-14.29 (-22.1)***	-15.53 (-23.6)***	-15.91 (-24.1)***
GDP per capita	0.0131 (0.18)	0.0281 (0.30)		
GDP per capita differential	-0.733 (-6.60)***	-0.601 (4.35)***		
Large GDP per capita differential (dummy)		- 2.86 (- 2.09)**		
Capital per worker			0.176 (7.35)***	0.134 (5.37)***
Capital per worker differential			-11.63 (-10.7)***	- 10.34 (-9.15)***
Large Capital per worker differential (dummy)				- 0.18 (-1.82)*
Land per worker differential	-0.373 (-5.87)***	-0.352 (-5.65)***	-0.469 (-7.08)***	-0.431 (-6.55)***
F-statistic	258.76	252.31	221.79	195.31
Adjusted R-squared	0.081	0.083	0.076	0.077
Observations	10468	10468	10468	10468

T-statistics in brackets. Level of significance of 10% (*), 5%(**) and 1% (***)

7. Conclusions

Our main aim in this paper has been to investigate, both theoretically and empirically, the relationship between endowment differences and the share of intra-industry trade. This was partly prompted by the contradictory empirical evidence on the effects of endowment differences on vertical intra-industry trade, with some authors finding a positive and others a negative relationship. To this end we constructed an illustrative theoretical model from which we drew inferences on the implications of small and large endowment differences for the shares of horizontal and vertical intra-industry trade. The predictions for horizontal intra-industry trade were quite conventional - that larger endowment differences would reduce such trade. But the predictions for vertical intra-industry trade were more factor and trading partner specific. The model predicted that vertical intra-industry trade would grow with differences in specific factor endowments, as long as these differences remain small. The effects of larger specific factor endowment differences depend on whether the specific factor is used by the industry. If not, then VIIT declines for larger endowment differences. If so, then the share of VIIT increases (decreases) if the trading partner has an ever larger (smaller) endowment. Our results on EU trade confirmed that horizontal intra-industry trade declines with growing endowment differences. They also confirmed the sensitivity of vertical intra-industry trade flows to the magnitude of endowment differences. The specific predictions on endowment differences in the specific factor used by the industry (assumed to be capital) were also confirmed. But the nonlinearities predicted for the other specific factor (assumed to be land) did not appear, perhaps due to insufficient variability in the sample.

These findings help to resolve the uncertainty that had arisen from earlier work on how vertical IIT varies with endowment differences. Because of its dominance in North-North trade it might be viewed as being affected by endowment differences in the same way as horizontal IIT. Equally the theoretical models of vertical IIT in North-South trade suggest a similar influence of endowment differences on both vertical ITT and inter- or net trade. Here we find a difference in the way endowments affect vertical IIT from both horizontal IIT and net or inter-industry trade. The share of horizontal IIT decreases for all increases in absolute endowment increases and the share of net trade increases for all increases in endowment differences with trading partners, but the share of vertical IIT both increases and decreases with increases in specific endowment differences. This finding supports the view that both within and between industry specialization

and trade can be driven by factor endowment considerations, and undermines the view that vertical IIT is simply disguised H-O trade associated with industry (mis)aggregation.

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