

NEW EVIDENCE ABOUT VERTICAL INTRA-INDUSTRY TRADE AND DIFFERENCES IN ENDOWMENTS

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Abstract

This paper studies the relationship between vertical intra-industry trade (VIIT) and differences in endowments. We present evidence that the share of VIIT between the European Union (UE) and its 51 major trading partners tends to increase for small differences in endowments and to decrease for wider differences in endowments. This suggests that the relation between VIIT and endowments does not follow the pattern of either horizontal IIT (HIIT) or of the net trade flows (as assumed by most former empirical studies about VIIT). This paper suggests a more complex relationship between VIIT and endowments, arguing that this is in accordance with the theoretical models. To study this we introduce new variables that relate VIIT to horizontal IIT and VIIT to net trade flows. The results suggest that the share of VIIT in total IIT increases with differences in endowments, and that net trade tends to increase more than VIIT when differences in endowments become wider. This evidence contributes to explain the pattern of VIIT. The results also suggest that VIIT assumes a leading role in the exchanges of factor services between countries with moderate differences in factor endowments while net trade dominates the net exchanges of factor services between countries with wider differences in factor endowments.

1. - Introduction

Differences in endowments (DE) play a central role in international trade theory, which establishes a clear relation between these and both net trade (NT) and horizontal IIT (HIIT). According to the Heckscher-Ohlin and the monopolistic competition models (Helpman 1981, Helpman and Krugman 1995), the share of net trade in total trade is expected to be bigger the wider the differences in endowments, while IIT (which was assumed to be horizontal) is supposed to be smaller.

Here we focus on the relation between VIIT and differences in endowments. It is of great importance to clarify this relation for at least two reasons. First, because empirical studies revealed that matched exchanges of vertically differentiated commodities is the dominant type of trade in most of the developed countries¹, suggesting that a large part of the net exchanges of factor services are embodied in VIIT rather than in net trade flows². Second because we argue that, contrary to what was assumed in most of the empirical studies about VIIT, the international trade models do not allow us to state clear predictions about VIIT and DE without an extra assumption.

Most of the former empirical studies about VIIT and DE assumed that the share of matched exchanges of vertically differentiated commodities in total trade should be bigger the wider the DE between any two countries. Here we show that the data suggests a more complex relation between vertical IIT and differences in endowments. We also argue that the contradictory evidence obtained by these studies may result from an implicit contra intuitive assumption about the relation between net trade and vertical IIT when DE became wider.

When we add a new assumption that considers in a sensible way (see section 5) the relation between VIIT and DE, this relation becomes either non monotonic or even contrary to what was assumed in former studies.

This is consistent with the descriptive evidence presented here (in section 4) for the European Union trade that suggests that the share of vertical IIT tends to increase

¹ E.g. Greenaway *et al.* (1994, 1999), Durkin and Krygier (2000), Blanes and Martin (2000) and Fukau *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.

with small differences in endowments and decrease for wider differences in endowments.

The new assumption introduced here allows us to draw some testable hypotheses about the relation between the DE and the shares of HIIT, VIIT and NT. To test these we follow the method used by Greenaway *et al.* (1994; 1995), disentangling vertical from horizontal intra-industry trade, 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.

In this paper we also introduce new dependent variables to study the relation between VIIT and HIIT and that between VIIT and NT, which are essential to understand the relation of vertical IIT with DE, considering the share of vertical IIT in total IIT and the ratio of vertical IIT to net trade as dependent variables. We also introduce new explanatory variables of VIIT, the square of the differences in the endowments in an attempt to adjust the regression models to a more complex relationship between DE and VIIT.

Section 2 presents the relation of the present work with both the theoretical and empirical literature. Section 3 presents the method to disentangle VIIT from HIIT. In Section 4 we present descriptive evidence and argue that it does not suggest that VIIT increases with DE, but either the opposite, or a more complex relation. Section 5 introduces a new assumption about the relation between DE and VIIT and NT. Section 6 presents the dependent variables, and discusses the expected signs according to the new hypothesis introduced in section 5. The regression results are presented in section 7. Section 8 presents the conclusions.

2. – Relation with the Literature

Differences in endowments explain net trade in the Heckscher-Ohlin model and are the most important determinant of the share of intra-industry trade (IIT) for the monopolistic competition models. The general equilibrium monopolistic competition models (Helpman 1981, Helpman and Krugman 1995) predict that the wider the differences in endowments the bigger will be the share of net trade flows and the smaller the share of IIT. In this context matched trade results only from scale economies and product differentiation.

These predictions of both the Heckscher-Ohlin and the monopolistic competition models implied that net trade should be bigger the wider the DE, while IIT (which was assumed to be horizontal) was expected to be smaller the wider the DE. Early studies about the determinants of IIT also suggested that IIT did not involve significant net exchanges of factor services and dominated North-north trade, while net trade embodied important exchanges of factor services and dominated North-South trade.

Recent work however revealed 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 (2005).

Vertical IIT models consider that matched exchanges of vertically differentiated commodities are explained by differences in endowments (between the countries) and in factor requirements within each industry. This is the case of the Falvey (1981) and Falvey and Kierkowski (1987) models, in which differences in capital per worker determined the level of quality of each variety. It is also true for the recent work of Gullstrand (2000) and of Gabszewicz and Turrini (2000), which present VIIT models where the production of high quality varieties requires a higher proportion of skilled labour³. Although these models present an explanation of VIIT based on differences in endowments they fail to establish a clear relation between VIIT and NT when DE increases – which is essential to establish the relation between VIIT and DE.

Early empirical work about determinants of IIT did not separate vertical from horizontal matched exchanges. 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 horizontal IIT C-H-O model.

Hummels and Levison (1995) cast some doubts about the robustness of these results, using direct measures of endowments (rather than GDP per capita) this study obtains results contrary to the C-H-O predictions. The work of Abd-el-Raman (1991) and Greenaway et al. (1994) established a method to separate vertical from horizontal IIT, presenting evidence that suggested that matched exchanges of vertically differentiated commodities are the dominant form of IIT, even in the trade between developed countries⁴.

³ Following these we also introduce variables based on skill endowments as determinants of IIT.

⁴The 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 the French trade in 1985-87, and by Durkin and Krygier (1997) for the US trade with the

The method used to disentangle vertical from horizontal IIT opened the door to econometric work that distinguished horizontal from vertical IIT. Most authors considered that determinants, and in particular the relation between each of these two types of IIT and DE to be clear and symmetric, expecting a positive correlation between DE and Vertical IIT and a negative correlation between horizontal IIT and DE.

The studies that run separate regression for horizontal and vertical IIT failed to confirm these expectations for VIIT, revealing contradictory results. Greenaway *et al.* (1994, 1999)⁵, Blanes and Martin (2000) and Fukau *et al.* (2003) obtained negative signs for the differences in GDP per capita when these are used to explain Vertical IIT, where it was thought⁶ that the Vertical IIT models predicted a positive sign. Gullstrand 1999, Martin-Montaner and Orts Rios (2002), Durkin and Krygier (2000), Crespo and Fontoura (2001) found positive signs for the same variable.

The use of direct measures of factors, as suggested by Hummels and Lehvinson (1995), was only applied in few of the empirical studies that separate vertical from horizontal IIT. Martin-Montaner and Orts Rios (2002) found positive and significant results for variables based on differences in endowments such as the differences in human capital and in capital per worker⁷. But Crespo and Fontoura (2001) present a negative sign for the case of differences in human capital⁸.

Here we argue that the approach followed by the earlier empirical studies, that used the Grubel and Lloyd index, was wrong in considering that vertical IIT would behave like horizontal IIT (in testing the C-H-O model using a index that gathers vertical and horizontal IIT together). But, we also argue that the hypothesis considered in the recent empirical studies that expect the share of vertical intra-industry trade flows in total trade to relate to differences in endowments in the same way as net trade, can

OECD countries in 1989 to 1992. In our calculations we obtained that vertical IIT accounts for 78% of the bilateral IIT between the UK and the OECD countries in 1996.

⁵Greenaway *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 per worker stock. This corresponded to what they expected for Vertical IIT, but not for Horizontal IIT, for which the same sign is reported.

⁶ Here we argue that the vertical IIT models do not really predict that Vertical IIT should increase with the increase of differences in endowments. We also show that evidence for the trade of the European Union points in the opposite direction.

⁷ 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 the result, that we argue below is interesting and valid but probably refers only to a type of Vertical IIT and not to the whole of Vertical IIT flows – see section 7.2.

⁸ Fukau *et al.* (2003) also consider differences in Human capital, but obtain non significant results.

not be inferred directly from the vertical IIT models⁹ and does not seem to reflect the real world data.

3 – Measurement of Horizontal and Vertical IIT

To determine if matched exchanges of a particular sector are considered as vertical IIT or horizontal IIT we follow Abd-el-Rahman (1991) and Greenaway *et al.* (1994) using the unit value of exports and imports. For each product the ratio of the unit value of exports to that of the imports determines the level of quality of the exports relative to the imports. For each of the sub-sectors j included in sector i :

$$\frac{UV_{ij}^X}{UV_{ij}^M}$$

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 . 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 horizontal intra-industry trade, while for values below or above it is considered vertical IIT¹⁰. The Grubel and Lloyd IIT index for the each type of trade flows * (Horizontal and Vertical IIT) 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 * (that is are considered to be horizontally or vertically differentiated).

⁹ There is no formal model that predicts the relation between vertical IIT and net trade. Both the Heckscher-Ohlin model, and the Vertical IIT explain trade from differences in endowments. For one to assume that the share of vertical IIT in total trade always increases with increases in the differences in endowments, one would have to consider that differences in endowments always lead to bigger increases in vertical IIT than net trade, which does not seem intuitive – for a discussion see Cabral (2004, 257).

¹⁰ When the price per unit (tone) of the exports exceeds that of the imports with a significant margin (the proportion given by the parameter α) will name the vertical IIT as high quality (VHQ), when it is below the interval that the vertical IIT is of Low quality (VLQ).

4 – Descriptive evidence

According to the interpretation of Vertical IIT models, followed by most empirical studies, the share of Vertical IIT in total trade should increase with differences in the endowments (and GDP per capita) between the partners. If this was the case a graph comparing the proportion of Vertical IIT in total trade with differences in endowments should show a positive slope. The evidence presented in the Graph 1 is far from suggesting that. At a first view the plot suggests just the opposite: a negative relation between vertical IIT and differences in GDP per Worker.

Facing this evidence, we could rush to conclude that the opposite of what has been assumed is true, admitting that vertical IIT relates to endowments in the same way as horizontal IIT: it diminishes with increases in the differences in GDP per worker¹¹.

The evidence presented in Graphic 2, that Vertical IIT tends to be bigger the more developed (level of GDP per worker) is the partner country of the EU, would only reinforce the previous idea, as it suggests that, as horizontal IIT, vertical IIT is also a North-North trade phenomena¹².

Graphics 3 and 4 show the relation between differences in GDP per worker and horizontal IIT and net trade. The two graphs present very clear pictures that are in accordance with theory. The share of horizontal IIT decreases with differences in GDP per worker, that of net trade increases with DE, just as the Chamberlain-Heckscher-Ohlin predicts. Also, when one plots for the level of GDP per worker (or per capita) the proportion of net trade in total trade tends to be smaller the bigger is the level of GDP per Worker, while the proportion of horizontal IIT tends to be bigger the bigger is the level of GDP per worker of the trading partner of the EU. This corresponds to the well establish idea that (horizontal IIT) takes place in the North-North trade, while inter-industry trade dominates the North-South trade.

After analysing these plots it is interesting to look back at that of Vertical IIT (Graph 1). The most we can say now is that it does not present a very clear picture. But for sure it presents one that is different both from that of horizontal IIT and of net trade. This picture suggests that Vertical IIT increases (or at least does not decrease) with the widening of the differences in GDP per worker between the countries, at least when

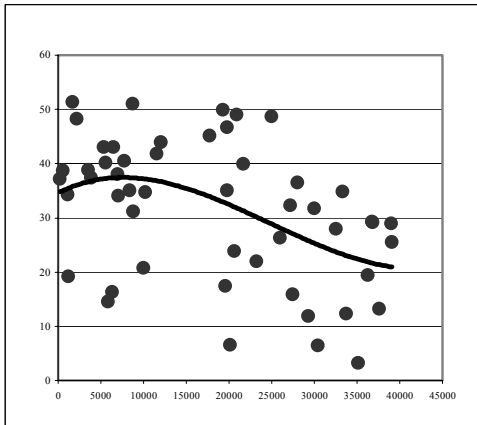
¹¹ Graphics for GDP per capita and Capital per Worker were also calculated. The plotted results are very similar for the relation of the share of vertical IIT in total trade with each of these three variables (GDP per Worker, GDP per capita or capital per worker).

¹² Although it is worth noting that the level of vertical IIT is much bigger, in particular in the trade between the EU and less developed countries.

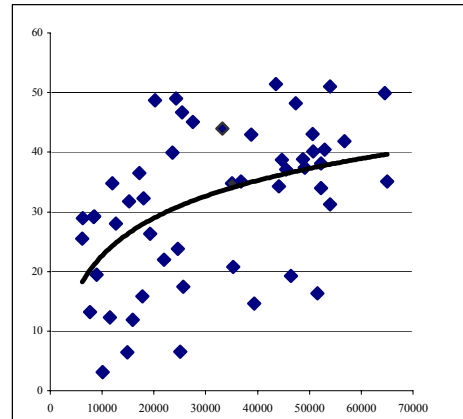
these are moderate, but for bigger differences in GDP per worker the proportion of Vertical IIT in the total trade tends to decrease¹³.

¹³ The graphic 1 suggests that the turning point is around 20000 dollars of difference in GDP per worker (or about 10000 dollars when GDP per capita is considered) – which is about 45% the EU average. It is also close the maximum difference registered for the upper side – that of the US.

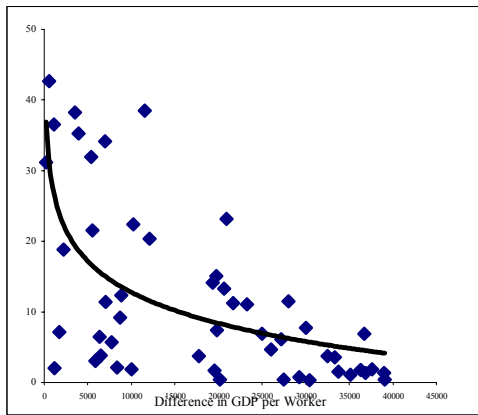
1 – Vertical IIT and Differences in GDP*



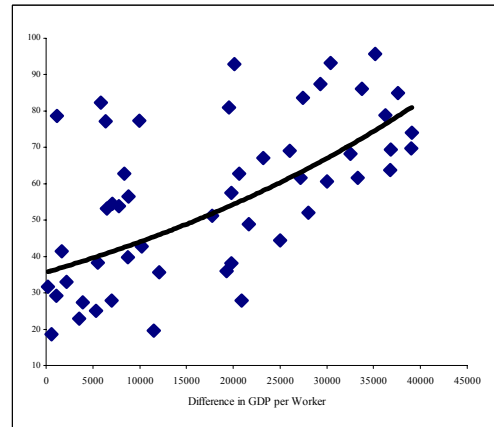
2 – Vertical IIT and Level of GDP**



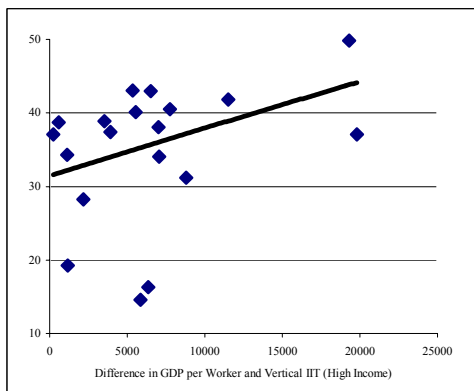
3 - Horizontal IIT and Differences in GDP*



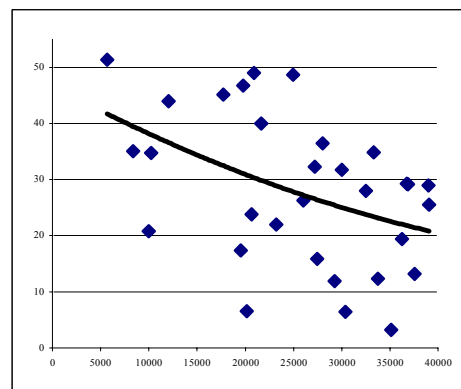
4 - Net Trade and Differences in GDP*



5 – High Income Developed Countries Vertical IIT and Differences in GDP*



6 – Middle Income and Developing Countries Vertical IIT and Differences in GDP*



* Each mark 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 Graph 2, the horizontal axis presents the level of GDP per Worker of each of the 51 countries.

The picture about vertical IIT becomes clearer when we separate the countries in our sample – in high income countries and middle and low income countries. The first group (presented in graphic 5) includes countries that are all very close or above the EU average, while the second group (graphic 6) includes countries that are all below the EU average.

The plotted results suggest a positive relation between vertical IIT and differences in the endowments for the first group of countries. This evidence is concordant with the results obtained in several studies that include only high income countries - e.g. Durkin and Krygier (2000), for the US with the OECD - or trade between middle income countries and high income countries - e.g. Martin-Montaner and Orts Rios (2002), for Spain with the OECD countries, or Gullstrand (1999) for the trade between Poland the European Union Countries¹⁴.

When one separates the countries in a way that one has only countries above the average the results expressed in differences became very similar to those expressed in levels, since the bigger the GDP per worker (or per capita) the bigger will be the difference in GDP per worker (in a sample chosen in this way).

On the other hand, since we are dealing only with countries with higher level of development most of the Vertical IIT will be of the type where the reference country exports the low quality varieties and imports the high quality ones¹⁵.

Adding the two facts, the evidence that, in the trade with the high income countries, vertical IIT is correlated positively with differences in endowments (or differences in GDP per capita) might mean that the IIT of low quality tends to be larger the larger is the income per capita or the capital per worker and Human capital endowments of the trading partner¹⁶.

¹⁴ Greenaway *et al.*(1999) note that the confirmation of the C-H-O hypothesis tends to be much stronger when the models are tested on samples that included countries with different levels of development, than in studies of groups of countries with similar level of development. This could be a result of the determinants of vertical and horizontal being different, when only small differences are considered.

¹⁵ The evidence presented here for the trade between the European Union and High countries (in Graphic 5) and that of the former studies that consider only trade with high income countries can be interpreted in the light of what should be expected for vertical IIT where the country assumes the position of exporting the lower quality varieties to more capital abundant countries. This is the case of the EU and High income countries, and that of the studies that consider trade between Spain (or Poland) and a group of countries with GDP per capita, capital per worker of human capital endowments superior to that of Spain (or Poland).

¹⁶ The same can be argued about the evidence in Graph 6. Here all countries have lower income per capita than the EU. So wider differences income are almost the same as lower income, and Vertical IIT will tend to be of the high quality type – in which the EU exports varieties of higher quality.

The conclusion here is that when studying vertical IIT in such type of samples one is mostly studying one type of vertical IIT and its relation with the level of endowments or income per capita¹⁷. The evidence obtained in those studies (e.g. Gullstrand 1999, Martin-Montaner and Orts Rios 2002, Gabrisch and Segana, 2002), should be seen as a confirmation of the determinants of the low quality type of Vertical IIT.

The evidence presented in graphics 5 and 6 suggests that the relation between the differences in endowments and vertical IIT should be expected to be given by a curve rather than be expected to fit in a linear and monotonous increasing or decreasing relation. This curve is that where we started, presented in graphic 1.

5. - New assumption and hypothesis

The discussion and evidence presented in the previous two sections suggest different hypothesis and variables to test the relation between Vertical IIT and differences in endowments. In this section we describe how we will test each of these hypotheses. We start by describing the hypothesis, and then the way in which we can use the data available to put it to the test.

The basic assumptions about the relation between differences in endowments and horizontal and vertical IIT and inter-industry trade suggest that a redistribution of resources that increases the difference in factor endowments:

- a) *Will decrease the share of Horizontal IIT in total trade (and increase the share of vertical IIT plus Inter-industry trade);*
- b) *Will increase the share of vertical IIT in total IIT.*

If we accept a new assumption that states that, at least after a certain point, Net trade will tend to increase more with differences in endowments than Vertical IIT, then, a redistribution of resources that increases the difference in factor endowments:

- c) *Will decrease the share of vertical IIT in the trade flows explained by differences in endowments (net trade plus vertical IIT)¹⁸;*

¹⁷ The evidence of the positive sign obtained in the variables for differences in endowments and in GDP per capita when only the High Income countries are considered, is consistent with that obtained by our study for the variables level of GDP per capita or level of Capital per Worker or Human capital for the Low quality Vertical IIT. We argue here that this happens because for samples with only high income developed countries these express the same features.

¹⁸ At least when samples include both developed and developing countries.

d) *Will decrease the share of total IIT in total trade;*

The hypothesis a) as been considered in the recent studies that, following Greenaway *et al.* (1994), present results for the determinants of horizontal and vertical IIT separately. There is some consensus about the hypothesis, although only a few studies present regressions for horizontal IIT and with contradictory results¹⁹.

The hypothesis d), about total IIT and differences in endowments was considered by the early studies about IIT, which considered that intra-industry trade would be of the horizontal type. Here we argue that, even if vertical intra-industry trade is the dominant type of matched trade flows, total IIT will still decrease with the increase in differences in endowments. This happens for two reasons first because we are assuming that Net trade flows will always increase and horizontal IIT will always decrease with the increase in differences in endowments, second because of the new assumption stated here.

The fact that most previous studies found that the share of total IIT in total trade tends to be smaller the bigger the differences in endowments, and the fact that this evidence was found even for countries for which most IIT is of vertical nature can be reinterpreted as evidence that favours the idea that the share of Vertical IIT in total trade, contrary to that of net trade, does not always increases with increases in the differences in endowments.

Since these two hypotheses have been addressed in previous studies we will focus here on hypothesis b) and c). We will address these directly, introducing new variables, and by considering the way in which these determine the relation between vertical IIT and differences in endowments. We argue that, from these two hypotheses, one may obtain a pattern where the share of Vertical IIT in total trade may increase with small differences in endowments and decrease for larger differences in endowments²⁰.

¹⁹ Confirmation of this hypothesis was obtained here and also by Blanes and Martín (2000), for differences in human capital and technological capital in Spanish trade, and Greenaway *et al.* (1994, 1999) for differences in income per capita in UK trade. Contrary results were also found, namely by Crespo and Fontoura (2001) for the variable differences in per capita income in the Portuguese trade and in Greenaway *et al.* (1999) for the variable differences in capital per worker. In both cases a positive and significant sign is reported when these are used as explanatory variables of horizontal IIT. Gabrisch and Segnana (2002) is another of the few studies that present regressions for the determinants of Horizontal IIT. This study also presents positive signs (although not significant) for the relation between differences in endowments and horizontal IIT for the case of the trade between the European Union and 4 eastern transition economies.

²⁰ This implies that the relation between the share of vertical IIT and differences in endowments will tend to be positive, when only countries with small differences are included in the sample, but will tend to be negative when countries with significant differences are included in the sample.

6. – Dependent Variables and Hypothesis

Vertical IIT

The discussion about the assumptions in the previous section, and the presentation of the evidence about the share of vertical IIT in total trade suggest that the relation between Vertical IIT and differences in endowments might not be as simple as was thought (a simple positive relationship). The curve for the share of Vertical IIT (Graphic 1 suggests a polynomial function rather than a linear relation).

Two hypotheses are suggested to study the relation between the share of Vertical IIT in total trade and differences in endowments. The first is that *the share of Vertical IIT in total trade will increase with small differences in endowments and decrease with larger differences in endowments.*

To test this hypothesis we present some of the variables that reflect directly or indirectly the differences in endowments in logarithms and in squares. Then we include these transformed variables simultaneously with the original variables. We argue that this hypothesis can be tested using differences in endowments simply and in the quadratic form. The expected signs will be positive for the logarithm variables and negative for the simple absolute value of the differences when these two variables are used together. When, alternatively, the squares of the differences are considered we would expect to find a negative sign for the quadratic and positive for the absolute value of the simple differences.

To test the hypothesis about big and small differences we will also introduce a dummy that is equal to one for the countries with significant differences in endowments. A hypothesis related to this and also suggested by the empirical evidence, both of the Graphic 1 and former studies is that: *the relation between the share of vertical IIT and differences in endowments tends to be positive, for samples that include similar countries and tend to be negative when countries with significant differences are included in the sample.*

To confront this hypothesis we will divide the sample of 51 countries into two sub-samples, one including mostly the high income and some middle income countries that have endowments that are not very dissimilar to those of the European Union, and another group of countries with wider differences in the relative endowments.

Vertical specialization

Hypothesis b) that the bigger the differences in endowments the bigger the share of Vertical IIT in total IIT results directly from the interpretation of the models, which suggest that the more the countries differ, the more IIT will tend to be based on matched exchanges of vertically differentiated commodities. To test this hypothesis we admit a new variable constructed from the former indexes that we name vertical specialization (VS). This variable is the proportion of vertical IIT in total IIT:

$$VS_{ict} = VIIT_{ict}/(VIIT_{ict} + HIIT_{ict})$$

Where $VIIT_{ict}$ and $HIIT_{ict}$ are, respectively, the volume of vertical IIT and of horizontal IIT in each industry i , between the EU and each partner country c and in each year t .

We will expect that the share of Vertical IIT in total IIT to be bigger, the bigger the differences in endowments and the lower the level of development of the EU trading partner. For some of these other independent variables it is more difficult to establish a clear prediction about the way these will affect vertical specialization²¹.

Vertical IIT to net trade ratio

Both vertical IIT and net trade models explain trade flows from by differences in endowments²². As we argue the relationship between Vertical IIT and net trade is not clear, and might be the key to explain the contradictory results obtained for the determinants of vertical IIT. We admit the new assumption that, at least after some point, differences in endowments will induce more specialization in different sectors than only specialization within sectors.

²¹ For example, distance should affect both types of IIT, but one may admit that it will affect horizontal IIT more than vertical IIT. In this case we will expect a positive sign for the variable (DIST), one might also predict a negative sign for the European Union Dummy, since we would expect that among the EU countries the level of Horizontal IIT will tend to be higher. Nevertheless note that for these two variables, as for those that reflect size of the countries it is more difficult to establish a clear prediction.

²² Recent empirical evidence also seems to confirm this. The evidence of the factor content study of Cabral, Falvey and Milner (2005) suggest that net exchanges of factors embodied in net trade are similar to those embodied in vertical IIT.

To study the relationship between vertical IIT and net trade and differences in endowments we will also introduce a new variable. This reflects the weight of Vertical IIT relative to that of Net Trade. The variable introduced, the ratio of vertical to net trade is given by:

$$RVNT_{ict} = VIIT_{ict}/NT_{ict}$$

Where $VIIT_{ict}$ and NT_{ict} are, respectively, the volume of vertical IIT and of Net Trade in each industry, between the EU and each country, in each year²³. According to the new assumption introduced we should expect a negative coefficient for the variables based in the differences in endowments when this variable is used.

7. – Regressions and results

In this next section we present the results of regressions about the determinants of VIIT. To establish the relation between DE and VIIT, we introduce new explanatory variables and use separate regressions for the High income and the Middle income and developing countries. We also introduce new dependent variables that clarify the relation between VIIT and HIIT - vertical specialization (VS), and the relation between VIIT and NT - the ratio of Vertical IIT to Net trade (RVNT) – which are central for the new assumptions introduced earlier.

The different regressions consider different dependent variables and several independent variables – see table The explanatory variables reflect either differences in endowments in alternative ways (using GDP per capita, capital per worker or human capital) or control variables that have been used in studies about determinants of IIT (such as distance, income level, being member of the EU)

The general model for the regressions is:

$$DEPENDENT_{ict} = C + \beta|E-E|_{ct} + \gamma OTHER_{ct}$$

Where the left side includes the different dependent variables described bellow, and the right side includes different specifications of differences in endowments and other control variables. We consider different specifications presenting results for

regressions using alternatively Ordinary Least Squares with robust standard errors, the Logistic equation and the Probit analysis²⁴.

Vertical specialization

The results presented in table 2 confirm that vertical specialization tends to be greater the larger are the differences in endowments. The signs obtained for all the alternative variables based in differences in endowments are positive meaning that bigger differences in endowments are associated with a larger proportion of the matched exchanges being vertical IIT. This is true for the proxies based on the differences in GDP per capita and GDP per Worker, and also for capital per worker²⁵.

These results are consistent with our hypothesis about the relation between vertical IIT and horizontal IIT, suggesting a confirmation of our interpretation of the models²⁶, which lead us to argue that matched exchanges that are not explained by differences in endowments (horizontal IIT) will tend to have a smaller relative importance in total matched exchanges the larger the differences in endowments.

Although this is the most important conclusion for the present discussion, it is also interesting to note that although the share of vertical IIT in total trade tends to be smaller the bigger the distance (see table...), within matched trade the opposite is true. Horizontal IIT seems to be affected more negatively by transport costs than the exchange of vertically differentiated products.

Variables that reflect the level of development (or the abundance of human and physical capital), present negative and significant signs as determinants of vertical specialization while presenting positive signs when used to explain the GL Vertical IIT

²³ Note that the ratio is presented in this form because the opposite would be undetermined for a large number of cases (where VIIT=0). Note also that the ratio presented for the share of Vertical IIT in total trade divided by the share of Net trade in total trade would result equal to this.

²⁴ Note that the Probit equations will be for a transformed variable that assumes the value 1 for the cases where the VS variable is bigger than 50%. For the case of RVNT variable the Probit equations are for the cases where the RVNT variable is bigger than 1.

²⁵ The absolute value of the differences in these variables obtained positive signs significant at the one percent level for all the different equations and specifications. Only the differences in the endowment of qualified labour received a less robust confirmation, with non significant coefficients for some of the specifications. Nevertheless, this variable obtained positive signs in all the regressions and several of these are significant at the 1 percent level. This variable is sensitive to the introduction of other variables (namely that of differences in capital per worker, and the EU dummy).

²⁶ Note that we refer to our interpretation since there is a gap in the theoretical literature about the relation between vertical IIT and horizontal IIT, since there are only separate models of horizontal IIT and models of vertical IIT. Nevertheless, we argued that the theory allowed us to establish a clear relation between

index²⁷. Vertical IIT tends to be bigger the more developed in the trade partner, but the share of vertical IIT in matched exchanges (vertical specialization) tends to be smaller the higher is the level of development. The EU dummy is also significant, presenting a negative sign.

Ratio of vertical to net trade

The results obtained for the ratio of vertical IIT to net trade are very clear. This ratio is smaller the larger the distance between the trading partners and the larger the differences in income per capita, in capital per worker or in qualified labour. The regression results are presented in table 7.2. These are consistent for the different specifications and to the inclusion of different variables²⁸.

This suggests a confirmation of the new assumption introduced by us. That is a confirmation that when differences in factors increase inter-industry trade replaces Vertical IIT. On the other hand the ratio tends to be bigger the higher is the income per capita the capital per worker and the share of high qualified labour. This shows that Vertical IIT tends to replace net trade in the exchanges of the richer and capital abundant countries. Net exchanges of factors between the rich countries are centred in vertical IIT.

Our interpretation of the results obtained here takes into account the results from the previous section, where we show that within the matched exchanges Vertical IIT increases with the differences in endowments, and those from chapter 5²⁹. There we show that vertical IIT includes important net exchanges of factors, net exchanges that seem to be as intense as those of net trade.

In the light of these different pieces of evidence, we argue that the results presented here suggest that Vertical IIT assumes a leading role in the exchanges of factors between the more developed countries and between countries that have moderate differences in their endowments and a less important role in the trade between countries with important differences in their endowments (North-South trade).

differences in endowments and vertical versus horizontal specialization, since the first is explained by differences in endowments while the later is not.

²⁷ This is particularly true for the case of capital per worker.

²⁸ In table 2 we present regressions using OLS robust standard errors estimations and estimations using the Logistic transformation. Regressions using the Tobit and Probit estimation methods were also run. These present results that are consistent with those from table 2.

²⁹ Note that in the next chapter we also show that differences in factor requirements within each industry are related in a positive and significant way with the share of vertical IIT.

As a comment to the results we also note that once more the results obtained for the income per capita based variables are very consistent with those for the differences in endowments.

Vertical and Horizontal IIT with North and South

Based on the previous studies that suggested that *the relation between the share of vertical IIT and differences in endowments tends to be positive, for samples that include similar countries and tend to be negative when countries with significant differences are included in the sample*, we divide the countries in two groups and run separate regressions for each of these.

Table 3 shows the coefficients for the regressions based on endowments and differences in the endowments for the trade of the EU with the *high income* countries and for the trade of the EU with the *middle income and developed* countries. When this distinction is made the sign becomes positive for the differences in endowments for the regressions using data from the high income countries, meaning that among these countries differences in capital per worker and labour per worker lead to higher levels of vertical IIT. For the developing countries the result are the opposite. The sign of the variable that reflects the differences in capital per worker is negative and significant. The evidence of contradictory signs for the endowment differences variables obtained for the two groups suggests a confirmation of the hypothesis that moderate differences in endowments might have a different effect on the share of vertical IIT than bigger differences.³⁰

Reinforcing this idea is also the result obtained by the variable land per worker³¹. The negative and significant result obtained both for horizontal and for vertical IIT suggests that countries with important endowments of land will specialize more in the traditional inter-industry trade way than within industries. Still focusing in the differences between the two estimates it is important to notice that the dominant type of vertical IIT is different in the two cases. For the case of the high income countries the trade of the EU is mostly specialized in vertical IIT of low quality – that is

³⁰ Note, nevertheless, that the results obtained for the variable based on the differences in the endowments of highly qualified labour are, in the case of the MID countries, less consistent with different signs and non significant coefficients showing in the different regressions.

³¹ The more significant divergences in land per worker of the countries considered are almost all for countries with higher levels of land per worker than those of the EU. For this motive the two variables become very similar.

in which the EU countries export the varieties of lower quality, while in the trade with the middle and developing countries the opposite happens.

Table 3 - Country-specific Endowment Variables.

OLS Robust Standard errors Independent Variables	High Income		Middle Income and Developing	
	HGL	VGL	HGL	VGL
GDP	0.171 (3.17)***	0.132 (1.84)*	0.021 (0.63)	0.110 (1.89)*
EU	0.75 (4.16)***	0.57 (2.34)**	0.35 (3.22)***	- 0.86 (-5.46)***
Distance	-0.833 (6.16)***	1.12 (-6.18)***	-0.298 (-3.75)***	- 1.31 (-10.19)***
Capital Per Worker	0.0018 st (4.37)***	0.0049 (0.09)		
Difference Capital p/worker	-0.841 (-3.23)***	0.452 (2.30)**	- 0.790 (-4.18)***	- 2.06 (-7.29)***
High Qualified Labour	16.91 (6.81)***	-3.02 (-0.92)		
Difference High Qualified L	-18.12 (-6.75)***	0.451 (2.21)**	-0.609 (-0.53)	1.12 (0.58)
F-statistic	157.44	63.44	67.5	107.14
Adjusted R-squared	0.0572	0.024	0.0239	0.0375
Observations	5157	5157	5444	5444

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

Vertical IIT with new explanatory variables

In analysing the evidence we argued that the relation between the share of vertical IIT and differences in endowments might be reversed when the range passes from small to bigger differences. We discuss that this might come from the relation between vertical IIT and net trade. Here we introduce explanatory variables that separate the different influences of the differences in factor endowments.

We will consider here not only the differences in endowments (and in GDP per capita as a proxy for the endowments) but also the squares of these differences, and

alternatively a dummy for big differences in the endowments. We try with these variables to capture the different roles of the smaller and bigger differences.

We define a dummy variable for the cases where the differences relative to the average value for the European Union are bigger than 50%. So we define that the Dummy variable BIGDGDPPC that:

Assumes the value 1, if $RDGDPPC_{ct} > 0,5$

And the value 0, if $RDGDPPC_{ct} < 0,5$

$$RDGDPPC_{ct} = DGDPPC_{ct} / AGDPPC_{UEt}$$

Where $DGDPPC_{ct}$ is, as formerly, the absolute value of the difference in GDP per capita between the European Union and $AGDPPC_{UEt}$ is the average GDP per capita of the European Union for each year.

We also introduce similar dummy variables for the variables difference in the endowment of capital per worker and difference in the endowment of high qualified labour³² (creating BIGDK/L and BIGDHQL).

In the present study we tried to go further in testing the relationship between total vertical IIT and endowments. The evidence suggests a more complex relation, suggesting that a unique variable may not be able to capture all the contribution of differences in endowments in explaining the variation of the share of vertical IIT.

This was the motivation for the development of the new variables presented in table 4. There we present a dummy that captures large endowment differences. As an alternative to this dummy we also considered the square and the logarithm of differences in endowments³³. When used simultaneously these variables should help us distinguish the effects of small differences in endowments, that we argue the evidence suggest contribute to increase vertical IIT, from the effects of wider differences that may lead to an increase in inter-industry.

³² In each of this cases the absolute value of the differences in the relative endowments is divided by the respective average endowment of the EU countries in capital per worker and in skilled labour.

³³ We use the square of the differences to capture the larger differences (when compared to the absolute value of the differences) and the logarithm for the opposite. The use of the squares of variables was done in the context of the determinants of IIT by Somma (1994) and by Fukao *et al.* (2003) for the variable Scale Economies. The reason was the same the fact that this variable presents contradictory results in many studies and, even according to theory, although being a necessary condition in some of the models, even these do not predict that the larger the scale economies the greater should be the share of IIT.

We expected the variables that captured the large differences to help separate the two types of effects that differences in endowments may have in IIT. So, we used these simultaneously with the variables that simply reflect the absolute differences.

According to the evidence, and the discussion in the previous sections we expected a positive sign for the simple variables and a negative sign for the squared variables and the big differences dummies.

The results did not give confirmation or denial to our hypothesis. These were mostly inconclusive. When used alone all the square variables and Dummies obtained the predicted negative sign. But when used together with the simple differences or variables that reflect level of income or of endowments several problems arise.

The square variables although presenting very significant coefficients are not robust. The coefficients change when other variables are included. Particularly when the variables that reflect the level of the endowments. These also change for the different specifications. So, any conclusions drawn from a set of regressions would be hiding opposite signs or non significant signs obtained for other specifications.

The squared variables were found to be strongly correlated with the simply differences and even with the variables in levels. Multicollinearity problems arise, with the variables presenting significant t-statistics in regressions where the coefficients of determination were quite low. In most cases these variables did not contribute to increase the explanatory power of the estimated models (measured either by increases in the adjusted coefficient of determination or by likelihood).

The Dummy variables for each of the measures of endowments were those that presented more consistent results. But even these, although presenting a negative sign did not contribute to change the sign obtained by the simple variables. So instead of capturing different (and opposite effects) these variables seem to be capturing the same negative sign. The only interpretation would be that large give a further contribute to decrease the share of vertical IIT in total trade. This result was also obtained in many of the regressions in which we introduce the squared and logarithm variables.

In the end the evidence suggested that for our sample a better and more consistent result could only be obtained using a higher polynomial specification for the variables. But in this case it would be very difficult to get straightforward conclusions with an economic meaning.

The contribution of the present work would have been enriched if we managed to adjust the relations we studied in a single simple formula. This was not possible, for the specifications we used and in the sample of countries considered.

8 . - Conclusions.

In this paper we present descriptive evidence that suggests that the relation between vertical IIT and differences in endowments is more complex than what has been assumed in former studies. We argue that this might be the cause of the contradictory results found in the empirical studies about the determinants of vertical IIT.

Here we follow a different approach, considering a new assumption about the relation between vertical IIT and net trade, and introducing new specific dependent variables to test it. The results obtained confirm that when differences in endowments became wider the net trade tends to dominate vertical IIT.

This evidence suggests a confirmation of our assumption. Added to that obtained for the relation between horizontal IIT and vertical IIT it can explain the more complex pattern of vertical IIT, and the fact that it tends to be positively related with differences in endowments for the trade between similar countries, while negatively correlated when countries with wider differences in endowments are considered. This implies that between countries with moderate differences in factor endowments vertical IIT plays an important role in the exchange of net services of factors, while between countries with wider differences in factor endowments, net trade dominates.

The evidence presented here shows that vertical specialization is explained by the theory. The signs reflect that vertical specialization increases with differences in endowments are in accordance with what the vertical IIT models and the Horizontal IIT models lead us to predict. This evidence suggests that, in accordance with theory, vertical IIT is explained by differences in endowments while Horizontal IIT is not. It can be seen as confirmation of the Falvey (1981) vertical IIT model.

The results presented here suggest that Vertical IIT assumes a leading role in the exchanges of factors between the more developed countries and between countries that have moderate differences in their endowments and a less important role in the trade between countries with important differences in their endowments. This is confirmed by the regressions for separate samples of developed (countries with GDP per capita

close to that of the EU) and Developing countries. These regressions suggest that in the trade between the developed countries vertical IIT is higher the greater the differences in factor endowments, while in the trade with the developing countries the opposite happens.

This evidence is consistent with that obtained by us in a factor content study that suggests that Vertical IIT may have a very important role (if not the most important) in the exchanges of factors between the High Income Countries (and between these and the Middle income Countries), but a less important role in conducting factor services in the trade between the high income and the Developing Countries.

Although we give an interesting contribution for the understanding of the relations between the different types of trade flows, and particularly of the place that vertical IIT seems to assume among these, we fail to find a particular specifications to express the relation between Vertical IIT and differences in endowments.

Table 1 – Determinants of Vertical Specialization

Independent Variables	Dependent Variable: Share of Vertical IIT in total IIT - VS = VIIT/IIT									
	OLSrse	OLSrse	OLSrse	OLSrse	OLSrse	Logistic	Logistic	Probit	Probit	
GDP	-0.0054 (-0.14)	-0.041 (-1.09)	-0.035 (-0.96)				-0.051 (0.82)	-0.278 (1.38)	-0.286 (1.39)	
EU	-0.728 (-6.57) ^{***}	-0.934 (-7.64) ^{***}	-0.930 (-7.62) ^{***}						-1.48 (-2.75) ^{***}	
Distance	0.389 (3.93) ^{***}	0.328 (3.17) ^{***}	3.18 (3.08) ^{***}	5.51 (5.60) ^{***}	6.75 (6.95) ^{***}	2.01 (1.13)	1.72 (1.15)	0.790 (1.27)	0.971 (1.66)	
Difference in GDP per capita	0.803 (10.16) ^{***}						6.02 (3.31) ^{***}		2.68 (6.20) ^{***}	
Difference in GDP per worker		0.044 (9.98) ^{***}								
Capital Per Worker			-0.218 (-8.73) ^{***}	-0.257 (-8.94) ^{***}		-0.924 (-2.31) ^{b)}		-0.599 (-5.08) ^{***}		
Difference Capital p/worker			0.441 (2.69) ^{***}	1.42 (10.36) ^{***}	1.63 (13.11) ^{***}	5.39 (3.42) ^{***}		2.33 (-2.86) ^{***}		
High Qualified Labour			-0.231 (-0.27)	-0.832 (-1.04)		-3.21 (-0.24)				
Difference High Qualified L			7.21 (1.44)	7.18 (3.58) ^{***}	12.43 (6.57) ^{***}	7.31 (0.49)		7.78 (1.78) [*]		
Adjusted R-squared	0.059	0.060	0.063	0.056	0.046	0.018	0.016	0.0286	0.275	
Observations	9291	9291	9291	9291	9291	2917	2917	10604	10604	

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

Table 2 – Determinants of the Ratio of Vertical IIT and Net Trade

Independent Variables	Dependent Variables										
	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT OLSrse	V/NT Logistic	V/NT Logistic
Distance	-14.21 (-22.0)***	-11.92 (-19.1)***	-15.34 (-23.8)***	-14.78 (-20.5)***	-16.34 (-25.3)***	-15.17 (-22.1)***	-14.97 (-20.9)***	-15.34 (-22.7)***		-12.28 (-25.8)***	-12.09 (-26.9)***
GDP per capita	0.0057 (0.07)		0.0292 (0.34)	0.613 (4.55)***						0.226 (0.41)	
Difference in GDP per capita	-0.767 (-6.90)***	-0.249 (2.33)**	-0.613 (4.55)***							-7.08 (-8.44)***	
BIGDGDPPC		-4.71 (-3.58)***	-2.82 (-2.06)**	-4.71 (-3.99)**						-8.68 (-1.30)	
Capital Per Worker						0.162 (7.12)***	0.170 (6.95)***				
Difference Capital p/worker					-9.02 (-8.08)***		-11.44 (-10.1)***	-10.09 (-8.5)***			-112.31 (-14.1)***
BIGD(K/L)					-0.17 (-1.77)*	-0.51 (-6.34)***		-0.17 (-1.71)*			-1.20 (-1.81)*
High Qualified Labour						0.162 (1.38)	0.271 (2.51)**				
Difference High Qualified L							-0.271 (4.47)***	-0.031 (0.66)			-7.11 (-1.86)*
BIGDHQL							-0.25 (2.94)***	-0.37 (-4.09)***			-5.14 (-9.59)***
Adjusted R-squared	0.079	0.081	0.081	0.079	0.073	0.073	0.080	0.079	0.172	0.163	
Observations	10468	10468	10468	10468	10468	10468	10468	10468	9274	9274	

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

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