THE ASYMMETRIC EFFECT OF ENDOWMENTS ON VERTICAL INTRA-INDUSTRIAL TRADE*

Juliette Milgram and Ana I. Moro **

WP-EC 2008-13

Correspondence: A. I. Moro: Universidad de Granada. Departamento de Teoría e Historia Económica. C/ Campus Cartuja s/n. 18071 Granada. Spain. Phone: (34)-958.24 10 00 / 20146. Fax: (34)-958.249.995. E-mail: aimoro@ugr.es

Editor: Instituto Valenciano de Investigaciones Económicas, S.A.

Primera Edición Octubre 2008

Depósito Legal: V-4542-2008

---

* The authors gratefully acknowledge financial support from the CICYT Projects SEJ2005-001163 and SEJ2006—11067 (Spanish Ministry of Education and FEDER) and Projects SEJ 340 and SEJ03261 of the Junta de Andalucía.

** J. Milgram, Ana I. Moro: Universidad de Granada.

THE ASYMMETRIC EFFECT OF ENDOWMENTS ON VERTICAL INTRA-INDUSTRIAL TRADE

Juliette Milgram and Ana. I Moro

ABSTRACT

This paper investigates the determinants of Spanish vertical intra-industry trade with a large sample of countries. We empirically test the comparative advantage explanation. For this aim, we build physical, human and technological capital stocks. On average, when using OLS techniques, differences in endowments are a limitation for vertical intra-industry trade. Using quantile regressions techniques, we observe that this negative effect decreases in absolute terms as vertical intra-industry trade flows increase and, in some cases, become positive for the upper tails, thus supporting the view of a reduced version of the comparative advantage explanation.

Keywords: Intra-industry trade, Comparative Advantage, Vertical Differentiation, Capital Stocks, Quantile Regressions.

JEL Classification: F11, F12, F14, C23, C24.

RESUMEN

Este artículo trata de analizar los determinantes del comercio intra-industrial vertical en España con una muestra de países extensa. Se contrasta empíricamente la hipótesis de la ventaja comparativa. Con esta finalidad, hemos construido series de capital físico, humano y tecnológico. En media, cuando se utiliza la estimación MCO, las diferencias en dotaciones suponen una limitación al comercio intraindustrial vertical. Usando la técnica de regresión por cuantiles, se observa que este efecto negativo disminuye, en términos absolutos, a medida que los flujos de comercio intra-industrial vertical se incrementan y, en algunos casos, llegan a ser positivos en los cuantiles altos de la distribución. Este resultado ofrece evidencia a favor de una versión reducida de la hipótesis de la ventaja comparativa.

Palabras clave: Comercio Intra-industrial, Ventaja Comparativa, Diferenciación Vertical, Stocks de Capital, Regresión Cuantilica.

1. INTRODUCTION

In the last decades, literature on international trade has provided new empirical and theoretical insight concerning the explanation of vertical intra-industry trade. According to these new models, vertical intra-industry trade could be explained by the comparative advantage theory as in the Heckscher-Ohlin model since high and low quality products are produced with different intensities of capital and labour (Falvey, 1981 and Falvey and Kierzkowski, 1987). This argument has been refined by other authors, giving rise to a more heterodox explanation in line with the neo-Ricardian and neo-factorial models. Gabszewicz et al. (1981) argued that it is the qualification of labour that matters for the production of high quality products. Shaked and Sutton (1984) pointed out the role played by the differences in research and development expenditures, while Flam and Helpman (1987) focused on technology differences.

From the second half of the nineties onwards, the trade of vertical differentiated products has grown between developed and developing countries. The comparative advantage explanation is especially attractive for explaining this phenomenon since the differences in factor endowments among these partners may enhance the trade of different quality ranges, just like inter-industry trade. Another interesting point of this literature is that the nature of endowments should play an important role for quality differentiation. This is an important issue since physical, human and technological capitals are not homogeneously distributed among emergent countries. Additionally, it is also natural to expect that countries with a low level of development and capital-labour intensities will export low quality products without importing high quality products. Hence, low levels of intra-industry trade between countries with different endowments do not contradict the fact that low quality ranges may be associated with low capital to labour ratios. This pattern could be explained by the fact that countries did not reach a certain threshold level of the capital-labour ratio required for bilateral trade to occur. In this paper, we test two different hypotheses. First, we test whether the trade of vertical differentiated products between unequal partners can be explained by the comparative advantage hypothesis. Secondly, we test whether a more partial version holds for partners which reached a sufficient level of vertical intra-industry trade.

The comparative advantage explanation of vertical intra-industrial trade and the more heterodox versions that take into account the nature of endowments, have been successfully verified for developed partners[1]. However, only a few studies[2] have analyzed the determinants of intra-industry trade among high-income and emergent countries. Among them, only Crespo and Fontoura (2004) and Milgram and Moro-Egido (2005) have considered the different types of intra-industry trade and endowments. Crespo and Fontoura (2004) focused on Portuguese data and showed that differences

[1]See Greenaway et al. (1994, 1995), Fontagné et al. (1998), Greenaway et al. (1999), Blanes and Martin (2000), Durkin and Krygier (2000), Diaz-Mora (2002) and Martin and Orts (2001, 2002).

[2]Ray (1991), Clark and Stanley (1999), Aturupane et al. (1999), Kim and Keun-Yeob (2001), Crespo and Fontoura (2004), Milgram and Moro-Egido (2005) are examples of this type of studies. However, due to the difficulty of gathering data for these countries, these studies have several limitations.

in per capita endowment have a positive effect on vertical intra-industry trade. The authors also include the interaction between the GINI index and per-capita income difference and obtain a negative coefficient. However, the coefficients of the two variables should be interpreted jointly for different levels of the GINI index to reach definitive conclusions about how differences in endowments affect the dependent variable [3]. Milgram and Moro-Egido (2005) focused on the Spanish intra-industry trade with developed and developing countries. They found that intra-industry trade with Central and Eastern European, Asian and Mediterranean countries has increased considerably since 1995. They also provided a test of the comparative advantage explanation where differences in per capita endowments are proxied by investment flows, R&D expenditures and education expenditures. They found that differences in R&D expenditures increase vertical intra-industrial trade, while differences in investment lead to its decrease. To correct for the selection bias generated by the zero values, they used the Heckman estimation procedure[4]. They concluded that differences in physical investment flows play a role for intra-industrial trade to occur. However, the levels of vertical and horizontal intra-industrial trade are better explained by the proximity of partners, the similarity in development level and market size.

In this paper, we contribute to this literature in three different ways. First, we try to overcome two limitations that appear in the related literature about data. On the one hand, flows are not good proxies for endowments, especially when they are highly volatile and when countries display asymmetric shocks. On the other hand, related works that take stocks into account usually focus on OECD countries. Thus, we build stocks for physical, technological and human capital for a large sample of OECD and emergent countries. Secondly, many empirical models built to explain intra-industrial trade consider explanatory variables that are common to total volume of trade, but disregard the specific impact of these variables on intra-industrial trade. We correct this bias by introducing the lag value of the total volume of trade. Thirdly, we explicitly take into account the heterogeneity of sectors and countries by using a quantile regression (QR) technique. In contrast to the OLS technique, QR estimation allows us to check whether explanatory variables have different effects along the distribution of vertical intra-industrial trade.

The results from the OLS estimation indicate that differences in physical, technological and human capital stocks are, on average, a limitation for vertical intra-industry trade. QR estimations show that average levels of endowments have a positive and decreasing effect on vertical intra-industrial trade along the conditional distribution. Differences in endowments have, in general, a negative effect that decreases in absolute terms as vertical intra-industry trade flows increase. In some cases, the effect becomes positive for the upper tails, supporting the reduced version of the comparative advantage explanation.

[3]For a theoretical justification of how the interacted variable should be interpreted, see for instance Chunrong and Norton (2003).

[4]Martín and Orts (2001, 2002) also used the same techniques. Alternatively, Clark and Stanley (1999) used the Tobit specification.

This paper is organized as follows. In the next section the data is briefly described and some descriptive statistics are presented for a selected group of countries. In Section 3 the empirical model is presented, while Section 4 contains the econometric results. Some conclusions are provided in Section 5. The Figures and Tables are confined to the Appendix.

2. DATA

We follow Greenaway et al. (1994) to calculate the volume of vertical intra-industry trade between Spain and 188 countries for the 1999-2000 period. The method is described in detail in Appendix A. We use data from the Eurostat COMEXT database at the 8-digit level of disaggregation of the EU's Combined Nomenclature (CN). Product categories were adapted to the 15 industries of the NACE Clio R 25 classification.

In Table 1, we present some descriptive statistics for the shares of vertical intra-industrial trade and intra-industrial trade in total trade. We also display the ratio of each type of capital stock per-capita in each of the selected countries with respect to Spain. Our sample includes countries belonging to six different regions: the European Union (EU), the OECD, Latin America, New Industrialized Countries in Asia (NIC Asia), Central and Eastern European Countries (CEEC) and Mediterranean and North African Countries (MNA)[5].

Considering the share of vertical intra-industrial trade on total intra-industrial trade, we observe that the percentage of vertical intra-industry trade is larger than 50% in all cases[6]. The largest ratio corresponds to the group of NIC Asia (around 85%), followed by the OECD (around 80%). Horizontal intra-industry trade accounts for a small fraction of total intra-industry trade, with the exception of the EU where vertical intra-industry trade only accounts for two-thirds of total intra-industry trade. For countries in Latin America, MNA and CEEC the ratios are similar at around 75%. Inside groups, the largest variation appears among CEEC countries. However, if we consider the ratio of intra-industry trade to total trade, the order is different. Now, the largest ratio corresponds to countries in EU, where intra-industry trade is around 20% of the total trade. For the rest of the countries, the ratios are not larger than 10%, ranging from 9.4% in the OECD countries to 3.2% in Latin America countries.

As pointed out in the introduction, we build stocks for physical, technological and human capital. In the case of physical and technological capital stocks we use the perpetual inventory theory method. For the case of physical capital, we have,

$$K_t = (1 - \delta) K_{t-1} + INV_t$$

where K_t is the physical capital for the year t, δ is the depreciation rate and INV_t

[5] Although we consider a large number of countries, for some of the specifications we will estimate below, we only report descriptive statistics about countries for which data are available to build capital stocks.

[6] For purposes of simplicity, we only include comments on the average descriptive statistics by groups of countries and not by country.

Table 1. Descriptive Statistics

	$\frac{VIIT}{IIT}$	$\frac{IIT}{Vol}$	$\frac{PK_j}{PK_{Spain}}$	$\frac{HK_j}{HK_{Spain}}$	$\frac{TK_j}{TK_{Spain}}$
EU	0.661	0.197	1.163	1.007	3.169
Austria	0.693	0.120	0.435	0.939	0.781
Denmark	0.768	0.131	0.318	1.001	0.713
Finland	0.696	0.068	0.261	1.071	0.669
France	0.548	0.386	2.559	1.006	7.692
Germany	0.640	0.296	4.829	0.915	11.752
Greece	0.634	0.076	0.218	0.951	0.141
Netherlands	0.632	0.219	0.786	0.997	1.838
Sweden	0.730	0.118	0.423	1.049	1.952
United Kingdom	0.648	0.268	1.683	1.024	4.663
OECD	0.803	0.093	1.924	1.001	6.847
Australia	0.870	0.041	0.688	0.977	1.398
Canada	0.834	0.070	0.802	1.023	2.008
New Zealand	0.852	0.032	0.101	1.017	0.156
Norway	0.800	0.077	0.295	1.045	0.600
Switzerland	0.750	0.145	0.573	0.959	1.860
United States	0.756	0.155	10.22	0.979	39.75
Latin America	0.768	0.032	0.261	0.808	0.121
Argentina	0.800	0.041	0.424	0.937	0.249
Chile	0.835	0.015	0.082	0.834	0.087
Colombia	0.638	0.036	0.124	0.741	0.074
Costa Rica	0.722	0.012	0.015	0.718	0.005
Mexico	0.796	0.063	0.616	0.806	0.185
Venezuela	0.742	0.014	0.138	0.737	0.044
NIC ASIA	0.855	0.054	0.488	0.938	1.375
Korea	0.869	0.054	0.818	1.027	2.700
Malaysia	0.840	0.054	0.157	0.849	0.049
CEEC	0.728	0.038	0.026	0.930	0.032
Croatia	0.734	0.027	0.023	0.875	0.021
Estonia	0.735	0.012	0.017	0.994	0.005
Hungary	0.752	0.063	0.087	0.894	0.056
Latvia	0.740	0.010	0.041	0.943	0.005
Lithuania	0.697	0.029	0.013	0.980	0.008
Romania	0.748	0.052	0.006	0.859	0.071
Slovenia	0.698	0.076	0.025	0.975	0.055
MNA	0.752	0.077	0.108	0.920	0.320
Israel	0.746	0.085	0.156	0.984	0.525
Tunisia	0.761	0.066	0037	0.823	0.011

is the investment expenditure. The initial physical capital stock K_0 is calculated as follows

$$K_0 = \frac{1 + g_{GDP}}{\delta + g_{GDP}} INV_0$$

where g_{GDP} is the variation rate of GDP by year (base 1995) and INV_0 is expenditures on investment for an initial year[7]. The technological capital has been constructed using $R\&D$ expenditures.

To obtain a measure of human capital endowment, we consider the average years of schooling; one of the two proxies most often used in the literature (see Barro and Lee, 1993 for instance). This measure is calculated from the formula:

$$AYS = \sum_j (YR_j \times HS_j)$$

where j is the schooling level, YR_j is the number of years of schooling represented by level j and HS_j is the fraction of the population for which the $j-th$ level is the highest value attained[8].

To set the relative position of Spain, we consider the ratio of other countries' capital stocks per-capita to the Spanish one. In the case of physical capital stocks per-capita, on the one hand we observe that the EU and the OECD display, on average, a larger physical capital stock per-capita than Spain. Heterogeneity inside these groups is large. For example, the USA has around ten times more physical capital per-capita than Spain, but Canada only has 80% of the Spanish physical capital per-capita. On the other hand, MNA, NIC Asia, CEEC and Latin America's physical capital stocks per-capita do not even account for half of the Spanish level. Thus, the heterogeneity across countries in these groups is now smaller than before.

In the case of technological capital stock per-capita, not only do EU and OECD countries have more technological capital stock per-capita than Spain, but also the NIC Asia. Heterogeneity among countries in these groups is larger than in the others. Concerning human capital stock per-capita, almost all countries display a similar level to Spain, with the exception of Latin American countries, which display around 80% of the Spanish human capital stock per-capita.

3. EMPIRICAL MODEL

Trade of similar products is theoretically justified in a monopolistic competition framework where production operates under increasing returns to scale and consumers have a preference for variety (Krugman, 1979 and 1980; Lancaster 1980; Helpman, 1981). These facts explain why intra-industry trade generally takes place among similar and rich countries.

[7] For any country we have considered the particular initial year for which data is available.

[8] From the WDI dataset we have obtained the constant gross domestic product, constant gross domestic product per capita, population, investment, R&D expenditures and years of schooling.

To explain the existence of intra-industry trade among unequal partners, Helpman and Krugman (1985) considered differences in endowments. The key hypothesis of this model is empirically well-established and assumes that differentiated products are more capital-intensive. One implication is that there exists a positive relationship between the volume of intra-industry trade and the intensities in capital relative to labour of the trading partners. Furthermore, as a larger market allows for economies of scale to occur, similar and large markets will also lead to more intra-industry trade. Finally, large differences in capital-labour ratios among partners will decrease intra-industry trade. This theoretical framework translates into a commonly accepted empirical model to explain intra-industry trade where GDP is used as a proxy for market size and GDP per capita is used as a proxy for capital intensity[9].

Hence, models that focus on vertical intra-industry trade as we do, should consider the comparative advantage explanation and assume that capital intensities could play a different role. Namely, that differences in capital-labour ratios should enhance vertical intra-industry trade. Nonetheless, this hypothesis may only hold for some specific sectors and trade partners where the level of capital-labour ratios are high enough to allow for a supply and demand of products in different quality ranges.

To make our study more comparable with the related literature, we first estimate a benchmark specification where differences in GDP per capita are used as a proxy for capital intensities. Following this, we consider two other specifications where we include alternative proxies for endowments, namely flows or, our main contribution, measures of capital stocks.

We choose to explain the volume of vertical intra-industry trade rather than the share of vertical intra-industry trade over total trade. This last ratio is in line with the Adjusted Grubel-Lloyd Index (1975) that calculates the share of total intra-industry trade over total volume of trade. As pointed by Nillson (1999), this index could fail to reflect interesting features of intra-industry trade in cross-country studies. First, this ratio is unscaled and therefore does not reflect the absolute level of intra-industry trade. This distinction could be specially important for our sample since we could observe the same values of the index for countries that display either low or high absolute values of vertical intra-industy trade. Furthermore, the index may be misleading if all countries do not trade the same products what it is clearly the case. As we will explain later on, considering the volume of vertical intra-industry trade as the dependent variable, allows us to capture the main explanations of the absolute values of vertical intra-industry trade and not only of its intensity.

Denote the volume of vertical intra-industry trade as $VIIT^j_{kt}$, where j represents the Spanish trade partner and k the industry. The benchmark model (Model 1) takes the following form:

$$\begin{aligned} \ln VIIT^j_{kt} &= \beta_0 + \beta_1 \ln DifGDP_{jt} + \beta_2 \ln AvGDP_{jt} + \beta_3 \ln DifGDPpc_{jt} \\ &\quad + \beta_4 \ln AvGDPpc_{jt} + \beta_5 X^k_j + \epsilon_{jkt} \end{aligned}$$

[9]See, for instance, the empirical models derived and discussed in Shelburne (2002), Hummels and Levinshon (1993, 1995) and Kim and Keun-Yeob (2001).

where $DifGDP_j$ is the difference in absolute terms of real GDP between Spain and its respective trading partner, $AvGDP_j$ is the average real GDP of Spain and its trading partner j, $DifGDPpc_j$ is the difference in absolute terms of per capita income between Spain and its trading partners and $AvGDPpc_j$ is the average per capita GDP of Spain and its respective trading partner. In vector X_j^k, we consider a group of variables such as *Distance* which is the geographical distance (in km) between the Spanish capital and the capital of country j introduced as a proxy for transportation costs; a dummy (EU) that takes the value of 1 if the trading partner belongs to the EU and 0 if not; the number of flows ($Nbflows_{jkt}$) built as the number of products traded at the 8-digit level in each industry k between Spain and country j; a dummy (*Contiguity*) that takes the value of 1 if the trading partner shares a frontier with Spain; a dummy for Common Language (*Comlang*) for countries where Spanish is the official language and finally, a group of dummies for sectors[10].

With the exception of the difference in GDP per capita, all the variables we consider are supposed to influence any kind of intra-industry trade in the same way and, in particular, the trade of vertical differentiated products. A large difference in economic size reflects both differences in demand and in supply sizes and is supposed to reduce any kind of intra-industry trade. Therefore, we expect $DifGDP_j$ to have a negative influence. We assume that the demand, the production of differentiated goods and the intensity in capital-labour ratio are higher when income per capita increases. We then expect that $AVGDPpc_j$ is positively related to intra-industry trade. $AvGDP_j$ is introduced as a measure of market sizes. In line with the Linder hypothesis, external markets can be considered as an extension of the internal market and local demand stimulates the innovation of products. Since consumers have a high preference for varieties, a large market indicates a more diverse demand for differentiated goods. Economic size also reflects the supply potential and, therefore, the export potential of any kind of goods, but more likely of differentiated goods since the production of these goods operates under increasing returns to scale. The average economic size is therefore expected to increase the volume of trade.

Based on the "gravity" approach for international trade, we include another group of variables in order to adequately predict the level of trade. To capture possible specificities in bilateral trade costs between countries, we also include *Distance*, EU, *Comlang* and *Contiguity*. Like any trade barriers, distance is supposed to reduce any kind of trade. We expect that trading partners who maintain lower tariffs and non-tariff barriers, such as EU members, should face higher levels of any kind of trade. *Comlang* and *Contiguity* are expected to enhance the volume of trade in general and could have a specific impact on intra-industry trade. We also introduce the lag value of total volume of trade (*Lagvol*) that reflects all the determinants of the volume of trade. Thus, in the specifications that include *Lagvol* the coefficients of all the explanatory variables, in particular *Distance*, EU, *Comlang* and *Contiguity*, only capture their specific influence on vertical intra-industry trade since their influence on the volume of

[10] Variables denoted as Distance, Contiguity and Com. Lang are obtained from the CEPII dataset. Nbflows comes from Comext, Eurostat.

trade in general is controlled by $Lagvol$. These effects may differ from the ones they have on total trade because we don't know if proximity foster the exchange of products in different quality ranges. Futhermore, the corresponding coefficients are then similar to the ones we would obtain in a model where the dependent variable were the ratio of intra-industry trade over the lag of total volume of trade. Then, this specification would indirectly explain the intensity of vertical intra-industry trade in total trade.

The proxies for differences in capital-labour ratios have become the key-variable when explaining vertical intra-industry trade. Differences in qualities may be explained by differences in endowments and technologies, that is, by a specialization motivated by the comparative advantage. This is opposed to horizontal intra-industry trade, which is better explained by similarities of tastes and productions. In this sense, differences in capital-labour ratios could enhance vertical intra-industry trade, at least among rich partners. However, this is weakly corroborated in the literature when GDP per capita is used as a proxy. The phenomenon seems to be more complex especially when partners differ strongly in their endowments and also because the nature of endowments plays an important role for specialization in quality ranges. A positive sign for $DifGDPpc$ will lead us to accept a general version of the comparative advantage of vertical intra-industry trade without any restrictions. But a negative, or non-significant sign, will not allow us to reject a more reduced version of this proposal since our sample accounts for very heterogeneous countries. Thus, the comparative advantage explanation may only hold for countries that reached a certain level of endowments.

As pointed out before, we propose Model 2 and Model 3 where we include explicit measures of endowments. This allows us to investigate whether the nature of endowments also matters. Model 2 considers three types of flows[11] measured in per-capita terms: investment in physical capital, R&D expenditures and education expenditures. Model 3, which is our main contribution, incorporates physical, technological and human capital stocks per capita that we have built. In model 3 (respectively model 2), we consider the differences of those stocks (respectively flows) with respect to Spain ($DifPKpc$, $DifTKpc, DifHKpc$ for physical, technological and human capital, respectively) and the average level of these variables ($AVPKpc$, $AVTKpc$, $AVHKpc$, for physical, technological and human capital, respectively). If the general version of the Hecksher-Ohlin model applies for vertical intra-industry trade, we should find that the differences in physical capitals have a positive impact on vertical intra-industry trade. According to the heterodox version of the comparative explanation, specialization in quality ranges is driven by differences in human capital stocks and/or differences in technological capital stocks, which should enhance vertical intra-industry trade. Nevertheless, a negative sign for one of these measures of the difference in endowments will lead us to reject the hypothesis that the comparative advantage theory is suitable for explaining vertical industry trade among heterogeneous countries. Hence, we should investigate the conditions for this proposal to apply.

[11] This model is directly comparable with Milgram and Moro-Egido (2005).

4. ECONOMETRIC RESULTS

Our empirical results are divided into two parts. The first part is a test of the Hecksher-Ohlin, neo-Ricardian and neo-Factorial explanations of vertical intra-industry trade flows among trade partners with different levels of development using OLS regression. The second part provides a complementary empirical strategy to test whether the explanation differs among quantiles using QR techniques. We consider the 1996-2000 period. All the tables are relegated to Appendix B.

4.1. OLS regressions

The outstanding feature of the estimation results reported in Table 2 is the robustness of the results, most of which are significant at the 1 percent level. The overall R-squared ranges from 0.67 to 0.84 depending on the specification. Specifications that include the lag of total volume of trade (Model 1b, 2b and 3b) performed better than their counterparts. Actually, in all cases, the past volume of trade has a significant and positive effect on vertical intra-industry trade flows. As expected, this result indicates that the volume of vertical intra-industry trade is partly explained by the same determinants as overall volume of trade. Actually, the influence of the rest of the explanatory variables does not change, but slightly decreases. The R-squared increases, making these alternatives more accurate. For these reasons, from now on we will focus on the specifications that control for past volume of trade.

Concerning market sizes, $DifGDP$ and $AvGDP$, when significant, show the expected signs, namely negative and positive, respectively. Note that when stocks are introduced, these coefficients fall to become significantly different from zero (Model 3 and 3b). This result is consistent with theoretical predictions since the difference in demand size is not a specific motor of vertical intra-industry trade but more definitively influences horizontal intra-industry trade. Concerning traditional variables of the gravity equation, the impact of distance is always negative and very significant, thus showing that trade costs have a specific influence on vertical intra-industry trade. The other proxies for specific ties, like $Contiguity$, EU, $Comlang$ also have, in general, a positive and specific impact on vertical intra-industry trade

Let us turn to the impact of endowments on vertical intra-industry trade. When we consider the proxies $DifGDPpc$ and $AvGDPpc$ (Model 1 and 1b), we find that they negatively and positively affect the level of vertical intra-industry trade. As in most studies[12], the sign of $DifGDPpc$ is not in harmony with the pure comparative advantage explanation of vertical intra-industry trade.

When endowments are proxied by flows or stocks of physical, human and technological capitals, the same conclusion applies: differences in endowments are generally an impediment for vertical intra-industry trade. Additionally, the estimation results point out that the building of stocks is not a worthless task since the models that

[12] See for instance Blanes and Martin (2000), Crespo and Fontoura (2004) or Milgram and Moro-Egido (2005).

Table 2. OLS Estimation (1996-2000)

Log VIIT	Model 1[(a)]	Model 1b[(a)]	Model 2[(b)]	Model 2b[(b)]	Model 3[(c)]	Model 3b[(c)]
DifCGDP	−0.568*** (0.033)	−0.263*** (0.028)	−0.340*** (0.032)	−0.160*** (0.026)	0.052 (0.033)	0.006 (0.027)
AvCGDP	2.362*** (0.079)	0.951*** (0.072)	2.102*** (0.101)	0.776*** (0.089)	0.202* (0.109)	0.102 (0.096)
DifCGDPpc	−0.269*** (0.041)	−0.166*** (0.034)				
AvCGDPpc	0.836*** (0.093)	0.756*** (0.078)				
Distance	−0.505*** (0.043)	−0.264*** (0.036)	−0.797*** (0.058)	−0.469*** (0.048)	−0.980*** (0.052)	−0.632*** (0.048)
Nb flows	0.006*** (0.000)	0.002*** (0.000)	0.004*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.001*** (0.000)
Contiguity	1.004*** (0.179)	0.574*** (0.149)	0.906*** (0.216)	0.325* (0.175)	0.479*** (0.185)	0.197 (0.164)
Com. lang	0.202*** (0.082)	−0.202*** (0.069)	1.086*** (0.117)	0.157 (0.098)	0.490*** (0.103)	0.027 (0.093)
EU	1.359*** (0.103)	0.689*** (0.087)	1.251*** (0.108)	0.458*** (0.090)	0.819*** (0.096)	0.393*** (0.086)
Lag Trade Vol.		0.824*** (0.017)		0.925*** (0.026)		0.745*** (0.028)
DifPKpc			−0.317*** (0.063)	−0.092* (0.051)	−0.167*** (0.033)	−0.088*** (0.029)
AvPKpc			1.940*** (0.385)	0.623** (0.312)	1.183*** (0.224)	0.671*** (0.199)
DifTKpc			−0.399 (0.803)	0.112 (0.648)	−0.467*** (0.053)	−0.272*** (0.047)
AvTKpc			−0.384 (0.900)	0.162 (0.725)	1.278*** (0.111)	0.724*** (0.100)
DifHKpc			0.071 (0.070)	−0.080 (0.056)	−0.083** (0.041)	−0.069* (0.037)
AvHKpc			−0.679** (0.328)	−0.034 (0.265)	−1.593*** (0.100)	−0.750*** (0.094)
intcpt	−38.56*** (1.802)	−29.13*** (1.508)	−696.8 (158.8)	−280.6 (128.1)	−28.68*** (2.446)	−24.76*** (2.158)
N	5252	5238	2450	2450	2450	2450
R^2	0.67	0.77	0.73	0.83	0.79	0.84
RMSE	1.905	1.581	1.601	1.291	1.416	1.249

Note: Standard errors in parentheses: ***, ** and * stand for statistical significance at the 1%, 5% and 10% levels respectively.

(a),(b),(c) Endowments measured by GDPpc, flows and stocks respectively include them perform better and reveal different insights, probably because flows are more volatile and influenced by business cycles. Differences in R&D and education expenditures are not significant, while technological and human capital stocks are. Our results confirm that the nature of capital is important for vertical intra-industry trade. In particular, technological aspects are more relevant than the other two. These results confirm part of the results of Blanes and Martin (2000) for Spanish trade with the OECD and Diaz-Mora (2002) for intra-EU trade. Both studies found that differences in human or technological capital have a more obvious effect on vertical intra-industry trade than physical capital differences.

Concerning the specification of our empirical model, we obtain more robust results[13] than Milgram and Moro-Egido (2005) due to the modifications we introduced. Our Model 1 here is comparable to Model 2 presented in Milgram and Moro-Egido (2005), although the sample of countries and the period are larger in our study. Moreover, our Model 2 is very similar to their Model 3, except that our study does not take into account the GINI index since it is too closely correlated with expenditures in education. Another difference is that, in this work, we systematically introduce the average level and the difference of any of the three indicators of stocks or flows. The reason for this is that introducing endowment differences without average levels could distort the results. For instance, this could be the reason why the impact of R&D differences is positive in Milgram and Moro-Egido (2005), while here it is not.

4.2. Quantile regressions

Since we are interested in explaining vertical intra-industry trade among unequal partners by sectors, our sample is, by definition, heterogeneous. QR techniques allow us to check if the determinants of vertical intra-industry trade differ depending on the level of these flows. In contrast, OLS assumes that the relationship between endowments and vertical intra-industry trade is the same along the conditional distribution. Unlike OLS, which gives information about the effects of the regressors at the conditional mean of the dependent variable, QR techniques provide information about the effect of explanatory variables along the distribution of the dependent variables. In QR techniques, the estimated regression coefficients can be interpreted as the marginal change in the volume of vertical intra-industry trade at the k-th conditional quantile due to a marginal change in the explanatory variable. Specifically, differences across quantiles represent differences in the volume of vertical intra-industry trade between country-sector pairs that are apparently similar, but located at different quantiles. The quantile regression model can be written as:

$$\ln VIIT_j^k = X_{jk}\beta_\theta + e_{\theta i} \qquad \text{with } Quant_\theta \left(\ln VIIT_j^k \mid X_{jk}\right) = X_{jk}\beta_\theta$$

[13] The different specifications have been estimated for the specific years 1996 and 1999 and also for the 1996-2000 period, using either panel estimation with random-effects or OLS. For panel regression, we use the random-effects approach which is more accurate since we have various time-invariant variables (distance, language, contiguity). In both cases, we introduce fixed effects by sectors. Here we present the results of the OLS estimations for the 1996-2000 period.

where X_i is the vector of exogenous variables and β_θ is the vector of parameters. $Quant_\theta \left(\ln VIIT_{jt}^k \mid X_i \right)$ denotes the θth conditional quantile of $\ln VIIT$ given X. Define the check function $\rho_\theta(z) = \theta z$ if $z \geq 0$ or $\rho_\theta(z) = (\theta - 1) z$ if $z < 0$. The θth regression quantile, $0 < \theta < 1$, is then defined as a solution to the problem

$$\min_{\beta \in R^k} \left\{ \sum_i \rho_\theta \left| \ln VIIT_j^k - X_{jk}\beta_\theta \right| \right\}$$

This problem is solved using linear programming methods. Standard errors for the vector of coefficients can be obtained by using the bootstrap method described in Buchinsky (1998). Note that if the underlying model were a location model, that is, if changes in explanatory variables only produced changes in the location of the conditional distribution of vertical intra-industry trade flows, but not in the shape of it, then all the slope coefficients would be the same for all θ.

Quantile regression is applied at five quantiles, namely at the 0.10, 0.25, 0.50, 0.75, and 0.90 quantiles and a bootstrap procedure with 250 replications is carried out. Results for selected variables of Models 1b and Model 3b are reported in Table 3[14]. To check whether there are asymmetries on the effect of endowments, we also include the OLS estimated coefficients. The null hypothesis that the coefficients are equal between pairwise quantiles and across all quantiles is tested based on the variance-covariance matrix of the coefficients of the system of quantile regressions. The tests are reported in Table 4. We plot the parameters estimated by QR techniques together with the OLS coefficients in Figures 1-4.

Recall that Model 1b uses GDP per-capita as a proxy for capital intensities. In this case, the estimated parameters for the difference in factor endowments per capita are negative and significantly different from zero. Additionally, as shown in Figure 1, the impact of differences is higher when the bilateral flows of vertical intra-industry trade are lower. The pairwise tests and the F-test statistics confirm this trend. Note that, in this case, the OLS estimated parameter is not sufficient to sum up the whole effect of the variable.

Concerning Model 3b, which includes capital stocks, we find some important asymmetries. We plot the estimated parameters in Figure 2 and 3. Differences in physical, technological and human capital stocks have, on average, a negative effect (OLS estimated parameter). However, when considering QR estimated parameters, although the parameters are almost always negative, there are important differences among quantiles. In the case of differences in technological capital stocks per capita, $DifTKpc$, the effect of this variable is larger in absolute terms for low levels of vertical intra-industry trade. The pairwise tests and F-test statistics confirm that differences among quantiles are significant. In particular, the upper tail behaves differently from the rest. The estimated effect ranges from -0.348 in the 0.10th quantile to -0.076 in the 0.90th quantile. In the case of differences in human capital stocks per capita, $DifHKpc$, the effect is negative and significant only for the three lower quantiles. A difference in cap-

[14] All estimated results are available upon request from the authors.

Table 3. QR Estimation (1996-2000)

Log VIIT	OLS	Q10	Q25	Q50	Q75	Q90
Model 1b						
DifCGDP	-0.263^{***} (0.028)	-0.295^{***} (0.039)	-0.251^{***} (0.036)	-0.183^{***} (0.029)	-0.151^{***} (0.033)	-0.146^{***} (0.039)
AvCGDP	0.951^{***} (0.072)	0.986^{***} (0.160)	0.832^{***} (0.095)	0.649^{***} (0.067)	0.580^{***} (0.064)	0.533^{***} (0.077)
DifCGDPpc	-0.166^{***} (0.034)	-0.203^{***} (0.070)	-0.187^{***} (0.043)	-0.149^{***} (0.031)	-0.105^{***} (0.024)	-0.033 (0.022)
AvCGDPpc	0.756^{***} (0.078)	1.316^{***} (0.178)	1.123^{***} (0.107)	0.910^{***} (0.086)	0.529^{***} (0.056)	0.330^{***} (0.068)
Lag Tr.Vol.	0.824^{***} (0.017)	0.913^{***} (0.044)	0.958^{***} (0.028)	0.945^{***} (0.025)	0.913^{***} (0.026)	0.850^{***} (0.030)
Model 3b						
DifCGDP	0.006 (0.029)	-0.053 (0.050)	-0.032 (0.032)	0.034 (0.028)	0.022 (0.019)	0.003 (0.037)
AvCGDP	0.102 (0.096)	0.147 (0.242)	0.082 (0.121)	-0.068 (0.101)	0.038 (0.082)	0.074 (0.106)
DifPKpc	-0.088^{***} (0.029)	-0.070 (0.058)	-0.016 (0.036)	-0.071^{**} (0.030)	-0.041^{**} (0.019)	0.015 (0.030)
AvPKpc	0.671^{***} (0.199)	0.834^{**} (0.332)	0.828^{***} (0.288)	0.618^{***} (0.210)	0.271^{*} (0.167)	-0.225 (0.252)
DifTKpc	-0.272^{***} (0.047)	-0.348^{***} (0.114)	-0.314^{***} (0.070)	-0.298^{***} (0.059)	-0.185^{***} (0.052)	-0.076 (0.070)
AvTKpc	0.724^{***} (0.100)	1.102^{***} (0.215)	0.775^{***} (0.148)	0.785^{***} (0.120)	0.616^{***} (0.098)	0.562^{***} (0.136)
DifHKpc	-0.069^{*} (0.037)	-0.300^{***} (0.085)	-0.125^{*} (0.066)	-0.053 (0.045)	0.034 (0.031)	0.050 (0.035)
AvHKpc	-0.750^{***} (0.094)	-0.432^{*} (0.225)	-0.650^{***} (0.157)	-0.779^{***} (0.135)	-0.714^{***} (0.112)	-0.486^{***} (0.123)
Lag Tr.Vol.	0.745^{***} (0.028)	0.811^{***} (0.074)	0.836^{***} (0.052)	0.775^{***} (0.041)	0.794^{***} (0.036)	0.825^{***} (0.048)

Note: Standard errors in parentheses: ***, ** and * stand for statistical significance at the 1%, 5% and 10% levels respectively.

Table 4. Test of QR Estimation (1996-2000)

Model 1b											
DifCGDP	Q25	Q50	Q75	Q90	All	DifCGDPpc	Q25	Q50	Q75	Q90	All
Q10	0.18	0.00	0.00	0.00	0.02	Q10	0.80	0.45	0.15	0.02	0.00
Q25		0.01	0.01	0.02		Q25		0.30	0.04	0.00	
Q50			0.21	0.31		Q50			0.09	0.00	
Q75				0.87		Q75				0.00	
AvCGDP	Q25	Q50	Q75	Q90	All	AvCGDPpc	Q25	Q50	Q75	Q90	All
Q10	0.24	0.03	0.01	0.01	0.04	Q10	0.19	0.02	0.00	0.00	0.00
Q25		0.02	0.01	0.01		Q25		0.02	0.00	0.00	
Q50			0.25	0.15		Q50			0.00	0.00	
Q75				0.47		Q75				0.00	

Table 4 (Cont.). Test of QR Estimation (1996-2000)

Model 3b											
DifCGDP	Q25	Q50	Q75	Q90	All	AvCGDP	Q25	Q50	Q75	Q90	All
Q10	0.62	0.07	0.14	0.34	0.18	Q10	0.77	0.38	0.67	0.78	0.60
Q25		0.02	0.09	0.43		Q25		0.17	0.73	0.96	
Q50			0.64	0.43		Q50			0.26	0.27	
Q75				0.57		Q75				0.71	
DifPKpc	Q25	Q50	Q75	Q90	All	AvPKpc	Q25	Q50	Q75	Q90	All
Q10	0.27	0.99	0.62	0.18	0.10	Q10	0.99	0.51	0.11	0.01	0.03
Q25		0.11	0.50	0.49		Q25		0.40	0.06	0.00	
Q50			0.25	0.02		Q50			0.06	0.00	
Q75				0.05		Q75				0.03	
DifHKpc	Q25	Q50	Q75	Q90	All	AvHKpc	Q25	Q50	Q75	Q90	All
Q10	0.02	0.00	0.00	0.00	0.00	Q10	0.11	0.13	0.03	0.03	0.19
Q25		0.18	0.01	0.01		Q25		0.93	0.31	0.27	
Q50			0.03	0.04		Q50			0.15	0.12	
Q75				0.65		Q75				0.65	
DifTKpc	Q25	Q50	Q75	Q90	All	AvTKpc	Q25	Q50	Q75	Q90	All
Q10	0.73	0.64	0.15	0.02	0.01	Q10	0.28	0.14	0.24	0.82	0.19
Q25		0.80	0.08	0.00		Q25		0.31	0.68	0.32	
Q50			0.01	0.00		Q50			0.57	0.05	
Q75				0.06		Q75				0.03	

Figure 1: OLS and QR Estimated Coefficients in Model 1b

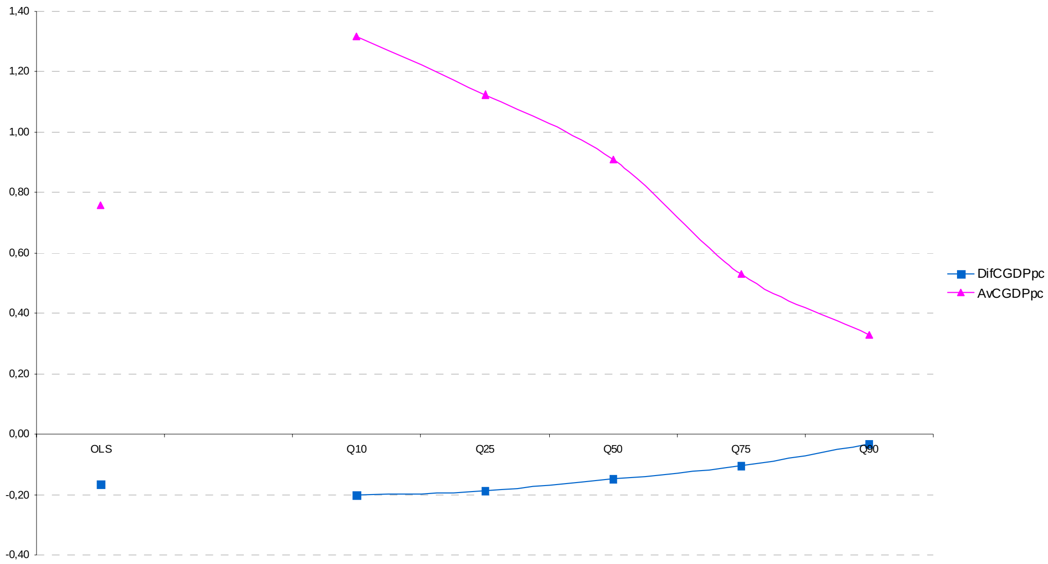


Figure 2: OLS and QR Estimated Coefficients in Model 3b

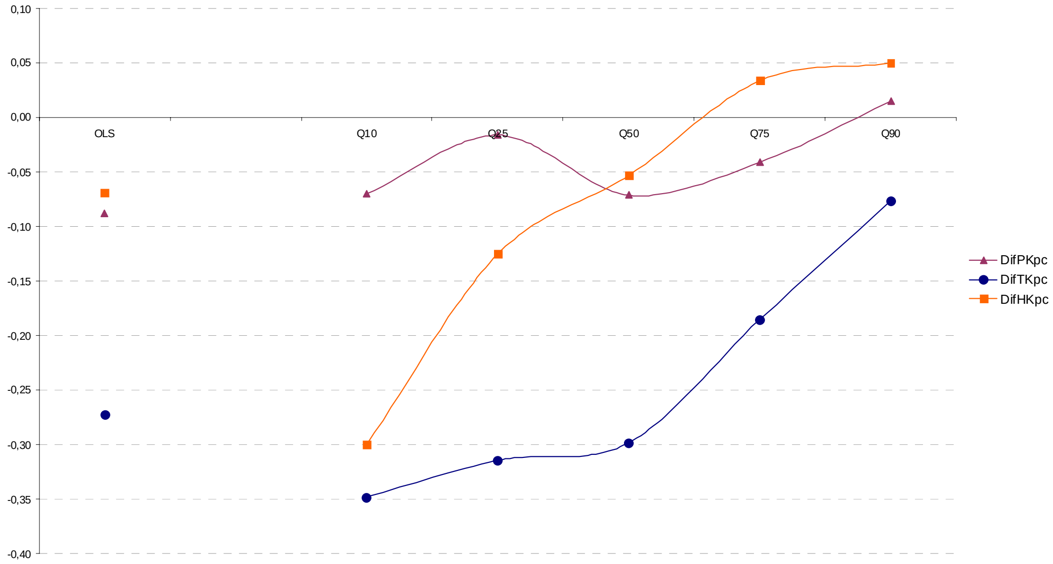


Figure 3: OLS and QR Estimated Coefficients in Model 3b

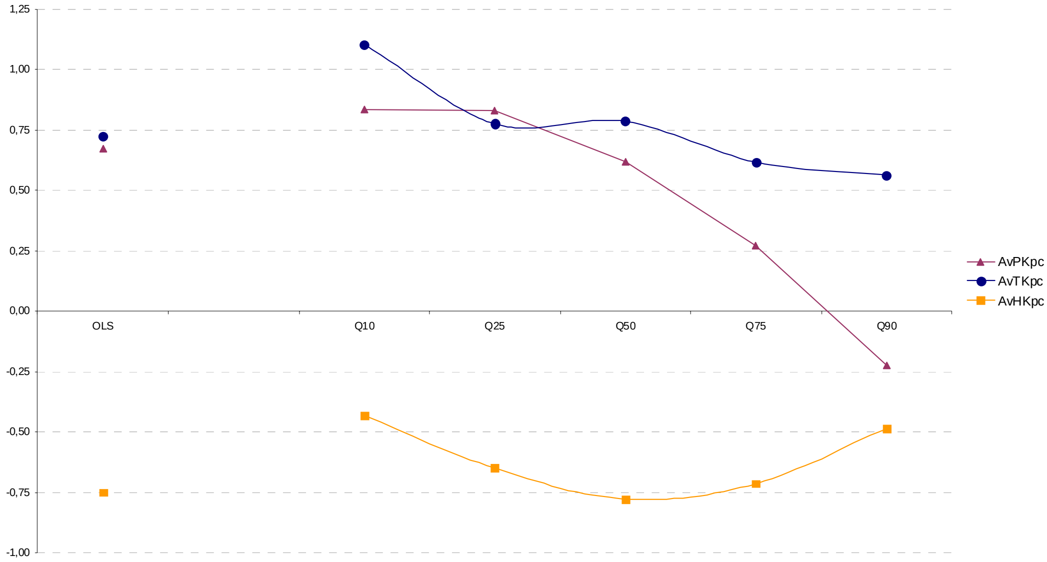
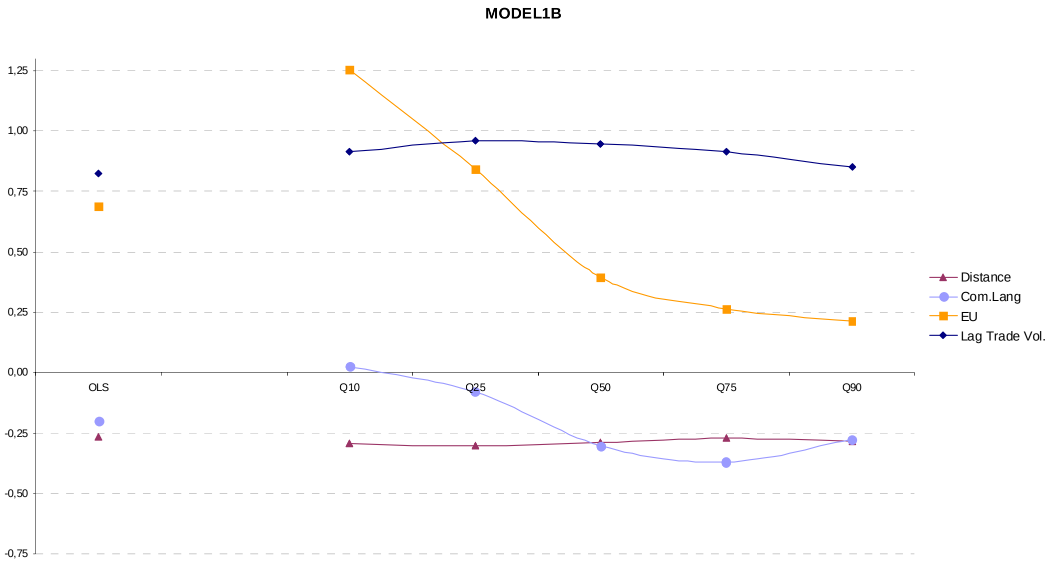
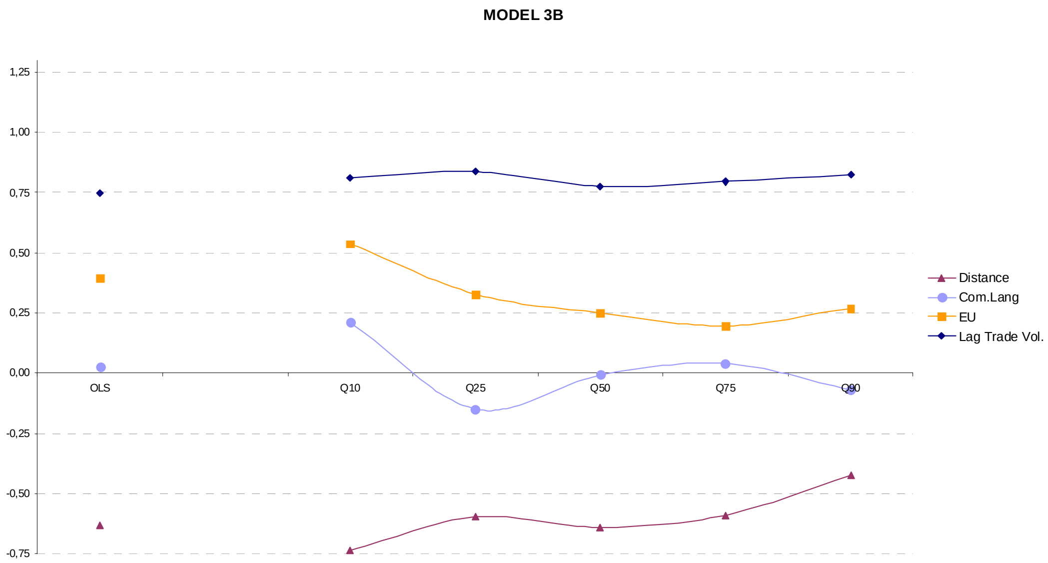


Figure 4: OLS and QR Estimated Coefficients of gravity equation variables





ital intensity is only an impediment for the three bottom quantiles of the conditional distribution since they probably have a lower level than the Spanish one. Finally, when we consider differences in physical capital stocks per capita, $DifPKpc$, QR estimation does not provide additional information to the OLS estimated parameter.

To sum up, the quantile regression reveals that differences in endowments are a greater impediment for lower levels of vertical intra-industry trade. Moreover, technological and human capital stocks are more relevant than physical capital stocks for vertical intra-industry trade.

Concerning the average size of endowments, the results are consistent with the OLS results, that is, the effect is positive and significant. The new finding is that the influence of these variables is smaller when vertical intra-industry trade is larger. As a consequence, vertical intra-industry trade with emergent countries that grow quickly could rapidly increase this type of flows. The over-all test and pairwise tests confirm that these differences along quantiles are significantly different from zero.

Figure 4 shows the estimated parameters for the usual variables of the gravity equation and the lagged volume of trade. We present the results for the specification of Model 1b and Model 3b. A general feature for $Lagvol$ is that the coefficients are relatively stable among quantiles. Although here we focus on the influence of endowments on vertical intra-industry trade volume, quantile regressions produce some interesting results concerning the gravity determinants. In particular, variables reflecting special ties like $Comlang$, $Contiguity$ and EU are systematically insignificant for the 75th and 90th quantile, while $Distance$ only matters for these highest flows. This means that trade costs are higher impediments for higher vertical intra-industry trade flows. For the lowest tail, $Comlang$ is the only variable reflecting proximity that appears to be significant, indicating that among developing countries, the Spanish speaking countries will have a higher level of intra-industry trade volume than others, independently of how far they are from each other.

5. CONCLUSIONS

This paper investigates the determinants of vertical intra-industry trade. One of the contributions of this paper is that it considers a general empirical model for a large sample of countries that jointly includes typical gravity variables, the past volume of trade and capital stocks, thus leading to more robust estimates. We show that not all the traditional determinants of inter-industry trade have a specific effect on vertical intra-industry trade, but variables usually introduced as proxies for transaction costs do. The construction of physical, human and technological capital stocks allows us to reach more precise conclusions compared with studies using income per capita as proxies for endowments.

We tested various hypotheses concerning the determinants of vertical intra-industry trade among different partners. Our results reject the hypothesis that the pure comparative advantage explanation is the main explanation for vertical intra-industry trade when countries with different endowments are considered. The results indicate that, on average, technological aspects and qualification of labour are decisive for this type of trade, while the impact of physical capital differences is not generally significant. The use of QR techniques leads us to accept a more reduced version of the comparative advantage explanation that applies to high bilateral flows (typically flows among rich countries). We show that the impact of endowment differences decreases in absolute value as volume of vertical intra-industry trade increases. Differences in physical and technological capital can even enhance vertical intra-industry trade for the upper tails of the vertical intra-industry trade distribution. This supports the idea of a mixed explanation for vertical intra-industry trade that combines neo-Ricardian and neo-factorial theories rather than a pure version of the Hecksher-Ohlin explanation of vertical intra-industry trade.

6. REFERENCES

1. Abd-el-Rahman, K..S. (1986) "Réexamen de la définition et mesure des échanges croisés de produits similaires entre les nations" *Revue Économique* 1, Paris.

2. Aturupane, C., Djankov, S., and B. Hoekman (1999) "Horizontal and Vertical Intra-Industry Trade between Eastern Europe and the European Union" *Weltwirtschaftliches Archiv* 135(1), 62-81.

3. Barro, R. and J.W. Lee, (1993). "International Comparisons of Educational Attainment". *Journal of Monetary Economics* 32 (3): 363-394.

4. Blanes, J. V., and C. Martin (2000) "The Nature and Causes of Intra-Industry Trade: Back to the Comparative Advantage Explanation? The Case of Spain" *Weltwirtschaftliches Archiv* 136 (3), 423-441.

5. Buchinsky, M. (1998), "Recent advances in quantile regression models: a practical guideline for empirical research", *Journal of Human Resources* 33, 88-126.

6. Chunrong A. , E. C. Norton (2003) "Interaction terms in logit and probit models", *Economics Letters* 80 (2003) 123–129.

7. Clark D. C. and D. L. Stanley (1999) "Determinants of Intra-Industry Trade Between Developing Countries and the United States", *Journal of Economic Development*, 24(2), December.

8. Crespo, N., and P. Fontoura (2004) "Intra-industry Trade by Types: What can we learn from Portuguese Data?' *Review of World Economic*, 140(I), 52-79.

9. Diaz Mora, C. (2002) "The role of Comparative Advantage in Trade within Industries: A Panel Data Approach for European Union" *Wetwirtschaftliches Archiv* 138 (2), 291-315.

10. Durkin, J.T., Krygier M. (2000) "Differences in GDP Per Capita and the Share of Intraindustry Trade: The Role of Vertically Differentiated Trade", *Review of International Economics* 8 (4): 760-774.

11. Falvey, R.E. (1981) “Commercial Policy and Intra-Industry Trade” *Journal of International Economics* 11, 495-511.

12. Falvey R.E. and H. Kierzkowski. (1987) “Product Quality, Intra-Industry Trade and (Im)Perfect Competition” in *Protection and Competition in International Trade* by H. Kierzkowski, Ed., Clarendon Press: Oxford, 143-161.

13. Flam, H., and E. Helpman (1987) ’Vertical Product Differentiation and North-South Trade” *American Economic Review* 77(5), 810-822.

14. Fontagné, L., and M. Freudenberg (1997) “Intra-industry trade: methodological issues reconsidered” CEPII Working Paper 97-01.

15. Fontagné, L., Freudenberg, M., and N. Peridy (1998) “Commerce international et structures de marché: une vérification empirique” *Economie y Statistiques* 135, 1998-4, 147-167.

16. Gabszewicz, J., Shaked, A., and J. Sutton (1981) “International Trade in Differentiated Products” *International Economic Review* 22(3), 527-534.

17. Greenaway, D. and C. Milner (1983) "On the Measurement of Intra-Industry Trade" *The Economic Journal* 93(372): 900-908.

18. Greenaway, D., Hine, R. C. and C. Milner (1994) “Country-Specific Factors and the Pattern of Horizontal and Vertical Intra-Industry Trade in UK” *Weltwirtschaftliches Archiv* 130 (1), 77-100.

19. Greenaway, D., Hine, R. C., and C. Milner (1995) “Vertical and Horizontal Intra-Industry Trade: a Cross-Industry Analysis for the United Kingdom” *The Economic Journal* 105, 1505-1518.

20. Greenaway D., C. Milner, R. J. R. Elliott (1999) "UK Intra-industry Trade with the EU North and South", *Oxford Bulletin of Economics and Statistics* 61 (3) , 365–384

21. Grubel, H.G., and P.J. Lloyd (1975) *Intra-Industry Trade*, London: The Macmillan Press Ltd.

22. Helpman, E. (1981) “International Trade in the Presence of Product Differentiation, Economies of Scale and Monopolistic Competition” *Journal of International Economics* 11(3), 305-340.

23. Helpman, E., and P.R. Krugman (1985) *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and International Economy*, Cambridge (Mass.): MIT Press.

24. Hummels, D.and Levinsohn, J. (1993) "Product differentiation as a source of comparative advantage", *American Economic Review*, 83 (2), 445.

25. Hummels, D.and Levinsohn, J. (1995) "Monopolistic competition and international trade: Reconsidering the evidence", *Quarterly Journal of Economics*, 110 (3), 799.

26. Kim, T. and O. Keun-Yeob (2001) "Country Size, Income Level and Intra-industry Trade", *Apllied Economics*, 33(3), 401-406.

27. Krugman, P. R. (1979) "Increasing Returns, Monopolistic Competition, and International Trade", *Journal of International Economics* 9 (4), 469-480.

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

29. Lancaster, K. (1980) "Intra-industry trade under Perfect Monopolistic Competition" *Journal of International Economics* 10(2), 151-175.

30. Martin, J.A., and V. Orts (2001) "A Two-Stage Analysis of Monopolistic Competition Models of Intra-Industry Trade" *Investigaciones Económicas* 25(2), 315-333.

31. Martin, J.A., and V. Orts (2002) "Vertical Specialization and Intra-Industry Trade: The role of Factor Endowments" *Weltwirtschaftliches Archiv* 138(2), 340-65

32. Milgram-Baleix, J. and A. I. Moro-Egido (2005): "Trade types with developed and developing countries. What can we learn from Spanish data?". *Economic Bulletin*, 6 (12), 1-17.

33. Nilsson, L. (1999) "Two-way Trade between Unequal Partners: The EU and the Developing Countries" *Weltwirtschaftliches Archiv*. 135(1), 102-125.

34. Ray E.J. (1991) "U.S. Protection and Intra-Industry Trade: The Message to Developing Countries" *Economic Development and Cultural Change*, 40 (1), 169-187

35. Shaked, A. and J. Sutton (1984) "Natural oligopolies and International Trade" in *Monopolistic Competition and International Trade* by H. Kierzkowski, New York: Oxford University Press.

36. Shelburne, R. C. (2002) "Bilateral Intra-Industry Trade in a Multi-Country Helpman-Krugman Model", *International Economic Journal*, 16 (4), 53-73.

7. APPENDIX A

Following Greenaway and Milner (1983), we define the volume of intra-industry trade (IIT) between Spain and country j for each 8-digit product p as the overlap between

Spanish exports X and imports M. For each industry k, IIT is obtained as the sum of IIT volume at the product level

$$IIT_k^j = \sum_{p \in k} IIT_p^j = \sum_{p \in k} 2 \min \left(X_p^j, M_p^j \right)$$

This measure of IIT allows for both geographic and industry aggregation (k can either be the total or any level of classification).

Intra-industry trade is then disentangled between horizontal and vertical intra-industry trade. Abd-el-Rahman (1986) assumes that differences in unit value calculated per ton reflect differences in quality. Greenaway et al. (1994) and Fontagné et al. (1997) use this methodology to differentiate between vertical and horizontal intra-industry trade. Therefore, if the export and import unit values differ less than $\pm\alpha$ percent, products are considered similar or horizontally differentiated. Otherwise, that is, if unit values of export and import differ substantially, this flow is considered as the trade of vertically differentiated products. Unit values of exports ($UV(X)$) and imports ($UV(M)$) are calculated at the most disaggregated level p and for each overlapping bilateral flow. Then, intra-industry trade of vertical differentiated products ($VIIT$) and intra-industry trade of horizontal differentiated products ($HIIT$) are obtained as follows

$$IIT_p^j = \begin{cases} HIIT_p^j & \text{if} \quad \frac{UV\left(X_p^j\right)}{UV\left(M_p^j\right)} \in [1-\alpha, 1+\alpha] \\ VIIT_p^j & \text{if} \quad \frac{UV\left(X_p^j\right)}{UV\left(M_p^j\right)} \notin 1-\alpha, 1+\alpha \end{cases}$$

where parameter α is an arbitrarily fixed threshold (usually equal to 0.15 or 0.25). Turning to the value of the parameter α that should be used, when a difference in unit values of more or less 15% is used, vertical intra-industry trade volume is correlated at 99% with the measure of vertical intra-industry trade when a margin of 25% is used. We checked that the choice of one of these two values for α, though arbitrary, did not have any substantial effects on the results of the estimations. Hence, we used a margin of 25%.