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# The Asymmetric Effect of Endowments on Vertical Intra-industrial Trade

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## 1. INTRODUCTION

IN the last two decades, Spain has reduced its income gap relative to the European Union average by half. But since Spanish activity has been accelerating sharply, Spanish inflation records are slightly above the euro area average (by 1 per cent since the launch of the single currency in 1999). Therefore, Spain suffers from a worsening of foreign competitiveness, especially towards the members of the eurozone (Pérez et al., 2004). Appreciation of Spain's real parities also makes it more difficult to compete with member countries, which can still benefit from an eventual depreciation of their exchange rate.

The deterioration of price competitiveness could have been compensated by improving quality, design, technology, technical assistance and so on, but the overall competitiveness of Spanish products has been damaged in recent years.[1] Finding ways of dealing with the increasing Spanish trade deficit has become a priority for the Spanish authorities. Like any country that has recently switched to the group of the richest countries, Spain needs to incorporate innovations

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[1] The Spanish market share in the eurozone and in the world increased from the introduction of the euro until 2003 and has decreased since then, especially in the eurozone. In 2007, its share of the eurozone represented 90 per cent of its share in 1999 and 98 per cent of its share of world imports in 1999.

better and compete in higher quality segments, exporting differentiated products that are more compatible with higher labour costs. This paper highlights some stylised facts regarding the recent insertion of Spain into the trade of quality-differentiated products and its determinants.

From the late 1990s onwards, Spanish trade in vertical differentiated products has grown along with 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 is that the nature of endowments should play an important role in quality differentiation. This is an important issue since physical, human and technological capitals are not homogeneously distributed among emerging countries. Additionally, it is also natural to expect countries with a low level of development and capital–labour intensities to 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.

The goal of this paper is to test whether the trade of vertical differentiated products between unequal partners can be explained by the comparative advantage hypothesis as well as testing whether a more partial version holds for partners which reached a sufficient level of vertical intra-industry trade. As mentioned before, this is an important issue for Spain, as it is an intermediate country whose price competitiveness has deteriorated in developed countries and that has recently started to export to emerging and developing countries.

In this paper, we contribute to this literature in four 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 emerging countries. Secondly, many empirical models built to explain intra-industry trade consider explanatory variables that are common to total volume of trade, but disregard the specific impact of these variables on intra-industry 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-industry trade. Finally, we also compare the expected and obtained results for other types of trade and study separately the determinants of low and high quality differentiated products to ensure the robustness of our previous findings.

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-industry 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. Complementary estimations confirm that the highest flows of vertical intra-industry trade share some features with inter-industry trade, in particular for low quality exports.

This paper is organised as follows. In the next section we review the existing literature to set the theoretical and empirical framework. In Section 3, data are briefly described and some descriptive statistics are presented for a selected group of countries. In Section 4, the empirical model is presented, while Section 5 contains the econometric results. Some conclusions are provided in Section 6.

## 2. THE THEORETICAL AND EMPIRICAL FRAMEWORK

In recent decades, literature on international trade has provided new empirical and theoretical insights 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, as pointed out in 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.

The comparative advantage explanation of vertical intra-industry trade and the more heterodox versions that take into account the nature of endowments have been successfully verified for developed partners.[2] However, only a few

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

studies have analysed the determinants of intra-industry trade among high-income and emerging countries. Ray (1991), Aturupane et al. (1999), Clark and Stanley (1999), Kim and Keun-Yeob (2001), Crespo and Fontoura (2004) and Milgram-Baleix and Moro-Egido (2005) are examples of this type of study. However, due to the difficulty of gathering data for these countries, these studies are subjected to several limitations: the period of study is old in order to use proxies for endowments from the Penn World Tables and/or they do not consider the different nature of intra-industry trade and/or use a very limited set of explanatory variables. Among them, only Crespo and Fontoura (2004) and Milgram-Baleix 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 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. Milgram-Baleix 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-industry 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.[3] They concluded that differences in physical investment flows play a role in the occurrence of intra-industry trade. However, the levels of vertical and horizontal intra-industry trade are better explained by the proximity of partners, the similarity in development level and market size.

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, 1980; Lancaster 1980; Helpman, 1981). These facts explain why intra-industry trade generally takes place among similar and rich countries.

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 is

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

a positive relationship between the volume of intra-industry trade and the intensities in capital relative to the 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 gross domestic product (GDP) is used as a proxy for market size and GDP per capita is used as a proxy for capital intensity.[4]

Hence, models that focus on vertical intra-industry trade, as ours do, should consider the comparative advantage explanation and assume that capital intensities could play a different role. Namely, those 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 levels of capital–labour ratios are high enough to allow for a supply and demand of products in different quality ranges.

## 3. DATA

We follow Greenaway et al. (1994) to calculate the volume of vertical intra-industry trade between Spain and 188 countries for the 1990–2000 period. We also divide vertical intra-industry trade into low and high quality ranges. Vertical intra-industry trade is considered of low quality when Spanish exports' unit values are substantially lower than their import counterpart and considered of high quality when the opposite holds. The method is described in detail in the Appendix. We use data from the Eurostat COMEXT database at the eight-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 concerning intra-industry trade, vertical intra-industry trade as a whole and by quality ranges in 2000. 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, newly industrialised countries in Asia (NIC Asia), Central and Eastern European countries (CEEC) and Mediterranean and North African countries (MNA).[5]

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

[5] Although we consider 188 countries, we only report descriptive statistics for the sample of 32 countries for which data are available to build capital stocks.

TABLE 1
Descriptive Statistics

| | $\frac{VIIT^{a}}{IIT}$ | $\frac{IIT^{a}}{TOT}$ | $\frac{VIITHigh^{a}}{VIIT}$ | $\frac{VIITLow^{a}}{VIIT}$ | $\frac{PK_j^{b}}{PK_{Spain}}$ | $\frac{HK_j^{b}}{HK_{Spain}}$ | $\frac{TK_j^{b}}{TK_{Spain}}$ |
|---|---|---|---|---|---|---|---|
| EU | 0.463 | 0.350 | 0.368 | 0.632 | 1.248 | 0.983 | 3.711 |
| Austria | 0.487 | 0.136 | 0.473 | 0.527 | 0.432 | 0.934 | 0.962 |
| Denmark | 0.695 | 0.131 | 0.475 | 0.525 | 0.313 | 0.985 | 0.752 |
| Finland | 0.641 | 0.047 | 0.342 | 0.658 | 0.254 | 1.062 | 0.621 |
| France | 0.352 | 0.438 | 0.393 | 0.607 | 2.522 | 0.994 | 8.474 |
| Germany | 0.589 | 0.355 | 0.342 | 0.658 | 4.644 | 0.893 | 14.044 |
| Greece | 0.458 | 0.068 | 0.555 | 0.445 | 0.218 | 0.951 | 0.133 |
| Netherlands | 0.558 | 0.215 | 0.427 | 0.573 | 0.776 | 0.985 | 1.736 |
| Sweden | 0.756 | 0.155 | 0.193 | 0.807 | 0.408 | 1.030 | 2.134 |
| United Kingdom | 0.505 | 0.320 | 0.357 | 0.643 | 1.668 | 1.013 | 4.546 |
| OECD | 0.830 | 0.151 | 0.276 | 0.724 | 2.120 | 0.997 | 7.267 |
| Australia | 0.949 | 0.029 | 0.240 | 0.760 | 0.689 | 0.978 | 1.216 |
| Canada | 0.762 | 0.062 | 0.487 | 0.513 | 0.807 | 1.022 | 1.980 |
| New Zealand | 0.914 | 0.013 | 0.434 | 0.566 | 0.101 | 1.017 | 0.177 |
| Norway | 0.815 | 0.031 | 0.364 | 0.636 | 0.293 | 1.035 | 0.496 |
| Switzerland | 0.839 | 0.160 | 0.186 | 0.814 | 0.562 | 0.952 | 2.028 |
| United States | 0.830 | 0.178 | 0.287 | 0.713 | 10.267 | 0.976 | 37.706 |
| Latin America | 0.662 | 0.032 | 0.469 | 0.532 | 0.254 | 0.808 | 0.093 |
| Argentina | 0.568 | 0.039 | 0.284 | 0.716 | 0.419 | 0.941 | 0.183 |
| Chile | 0.745 | 0.013 | 0.387 | 0.613 | 0.084 | 0.837 | 0.066 |
| Colombia | 0.612 | 0.037 | 0.529 | 0.471 | 0.121 | 0.742 | 0.055 |
| Costa Rica | 0.525 | 0.007 | 0.234 | 0.766 | 0.015 | 0.724 | 0.004 |
| Mexico | 0.710 | 0.042 | 0.569 | 0.431 | 0.616 | 0.804 | 0.170 |
| Venezuela, RB | 0.722 | 0.006 | 0.452 | 0.548 | 0.136 | 0.736 | 0.040 |
| NIC Asia | 0.902 | 0.044 | 0.476 | 0.524 | 0.489 | 0.933 | 1.269 |
| Korea, Rep, | 0.916 | 0.048 | 0.447 | 0.553 | 0.820 | 1.026 | 2.498 |
| Malaysia | 0.834 | 0.031 | 0.630 | 0.370 | 0.157 | 0.841 | 0.040 |
| CEEC | 0.519 | 0.093 | 0.330 | 0.671 | 0.030 | 0.932 | 0.021 |
| Croatia | 0.364 | 0.034 | 0.713 | 0.287 | 0.024 | 0.868 | 0.017 |
| Estonia | 0.943 | 0.008 | 0.397 | 0.603 | 0.017 | 0.990 | 0.004 |
| Hungary | 0.332 | 0.123 | 0.328 | 0.672 | 0.088 | 0.885 | 0.058 |
| Latvia | 0.944 | 0.012 | 0.838 | 0.162 | 0.039 | 0.949 | 0.004 |
| Lithuania | 0.855 | 0.020 | 0.901 | 0.099 | 0.013 | 0.988 | 0.007 |
| Romania | 0.829 | 0.041 | 0.727 | 0.273 | 0.002 | 0.859 | 0.026 |
| Slovenia | 0.922 | 0.147 | 0.199 | 0.801 | 0.026 | 0.985 | 0.054 |
| MNA | 0.734 | 0.098 | 0.273 | 0.727 | 0.096 | 0.902 | 0.320 |
| Israel | 0.667 | 0.102 | 0.381 | 0.619 | 0.156 | 0.978 | 0.629 |
| Tunisia | 0.864 | 0.092 | 0.113 | 0.887 | 0.036 | 0.826 | 0.011 |
| TOTAL | 0.489 | 0.300 | 0.359 | 0.641 | 0.858 | 0.937 | 2.606 |

Notes:
[a] For ratios concerning different measures of trade, the averages for regions are calculated as the weighted averages.
[b] For the ratios concerning stocks of capital, the averages are not the weighted averages.

The weighted average of intra-industry trade between Spain and the EU represents around 35 per cent of total Spanish trade. This type of trade is also important in Spanish trade with Switzerland, the United States, Hungary, Slovenia, Israel and Tunisia. For the rest of the countries, intra-industry trade represents less than 6 per cent of the total volume of bilateral trade. As pointed out by the literature, most intra-industry trade concerns vertical intra-industry trade (more than 45 per cent in all cases). The largest ratio of vertical intra-industry trade in intra-industry trade corresponds to the NIC Asia group (around 90 per cent), followed by the OECD (around 83 per cent), MNA (73 per cent) and Latin America (66 per cent). Horizontal intra-industry trade accounts for a small fraction of total intra-industry trade, with the exception of the EU and the CEEC where vertical intra-industry trade accounts respectively for 46 per cent and 51 per cent of total intra-industry trade. When vertical intra-industry trade is disentangled by quality ranges, we find that for more than 60 per cent of the Spanish volume of vertical intra-industry trade, unit values of exports are lower than their import counterpart. This is especially true for its trade with some OECD countries and MNA but also important for its trade with Hungary, Slovenia, Israel, Tunisia, Chile and Costa Rica. Milgram (2005) shows that a large part of EU trade in textiles and clothing with MENA, and especially with CEEC, consists of outward-processing trade where products are reimported after some small transformation in the partner country. This represents more than two-thirds of trade for this type of product with the CEEC and about 16 per cent of trade with Tunisia, for instance. As argued by Fidrmuc et al. (1999), these patterns should be taken into consideration when considering specialisation in quality ranges since low quality varieties of a high-tech product are counted in the low quality range, while high-priced varieties of simple products are included in the high range. Thus, when analysing the data, one should bear in mind that the definitions of high and low quality ranges are specific to a bilateral flow for a specific product. To conclude in relation to the upgrading or downgrading of Spanish exports, this study should be complemented by an analysis of quality ranges defined in a universal manner among products and partners.[6] Nevertheless, our data show that Spain tends to exchange low quality products in exchange for high quality products with the most developed countries and with the CEEC and Tunisia, which could be influenced by trade in outward processing.

In Figure 1, we can observe, for the main regions studied, the evolution of the above-mentioned shares throughout the 1990–2000 period. Intra-industry trade (IIT) takes up a great proportion of the Spanish trade with the EU but its

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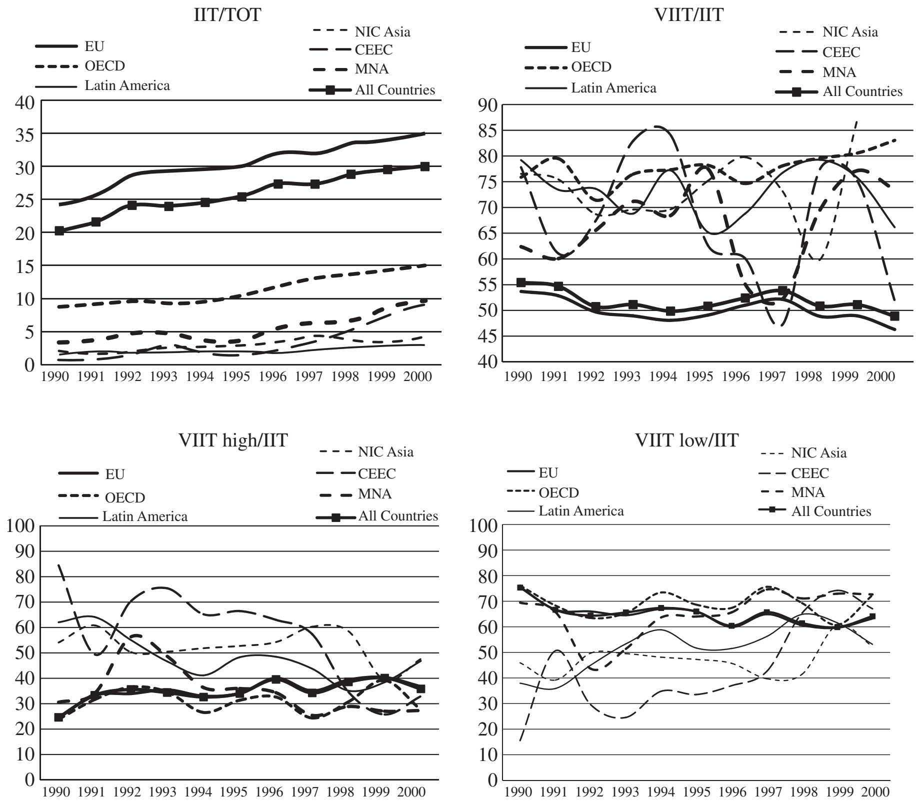
[6] For instance, Fontagné et al. (1995) show that Spanish exports to the EU in 1992 were mainly in the medium or low ranges compared to the EU average, while the composition of imports was more similar to that of the other members.

FIGURE 1
Evolution of Intra-industry Trade




share has increased slightly with emerging countries from 1995. The weight of vertically-differentiated products has especially increased in intra-industry trade with NIC Asia and MNA. For emerging countries, this share experiences large fluctuations. This must be explained by the rapid changes in the composition of their exports and by the fact that the methodology used to distinguish between vertical and horizontal trade may lead to instability in the type of flows if average unit values change considerably from one year to another. Nevertheless, as pointed out by Nielsen and Lüthje (2002), we are lacking an empirical method to solve this problem. As mentioned before, the most important feature is that this type of trade is largely dominated by low quality exports. These shares are relatively stable in Spanish trade with the richest countries like those of the OECD and EU. But low quality exports increased drastically in Spanish vertical intra-industry trade with the CEEC, though this is mainly the result of its trade with Hungary, Estonia and Slovenia, the richest CEEC countries in our sample. Another interesting feature is that the weight of low and high qualities in vertical IIT seems to converge among the different zones: in 1990, the weight of low quality exports ranged between 20 per cent for MENA and 75 per cent for OECD. In 2000, this share ranged from 55 per cent to 70 per cent. This clearly confirms that low quality is of greater weight in Spanish exports regardless of the destination.

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 $t$, $\delta$ is the depreciation rate and $INV_t$ is the investment expenditure.[7] 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 expenditure on investment for an initial year.[8] 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.[9]

[7] From the World Development Indicators Database dataset we have obtained the gross capital formation as a measure of the variable $INV_t$. For international comparisons across countries, we assume identical depreciation rates for all countries. Depreciation rate is also assumed to be constant over time. Since we do not have a suitable disaggregation in all types of assets for all countries, we are not able to predict the evolution of this rate adequately. Furthermore, an increasing depreciation rate for public capital but overall for private non-residential fixed assets is justified to take into account ICT that from 1995 have drastically affected the consumption of fixed capital in developed countries. However, as recommended by OECD (2001), the rate is assumed to be constant for private residential fixed assets and rather low. Following the OECD 2001 method, Kamps (2006) calculates an average depreciation rate of 4 per cent OECD countries at the beginning of the 1960–2001 period. Since we consider middle-income countries, we use this rate for the whole period and all the countries.

[8] For each country we have considered the particular initial year for which data are available.

[9] From the World Development Indicators Database we have obtained the constant gross domestic product, constant gross domestic product per capita, population, investment, R&D expenditure and years of schooling.

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. There is major heterogeneity inside these groups. For example, the USA has around 10 times more physical capital per capita than Spain, but Canada only has 80 per cent 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 greater 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 per cent of the Spanish human capital stock per capita.

## 4. EMPIRICAL MODEL

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 chose to explain the volume of vertical intra-industry trade rather than the share of vertical intra-industry trade over total trade. This latter 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 out by Nilsson (1999), this index could fail to reflect interesting features of intra-industry trade in cross-country studies. First, this ratio is not scaled and therefore does not reflect the absolute level of intra-industry trade. This distinction could be especially 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-industry trade. Furthermore, the index may be misleading if all countries do not trade the same products, which is clearly the case. As we will explain later on, considering the volume of vertical intra-industry trade as the dependent variable enables us to capture the main explanations of the absolute values of vertical intra-industry trade and not only its intensity.

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

$$\ln VIIT^{k}_{jt} = \beta_0 + \beta_1 \ln DifGDP_{jt} + \beta_2 \ln AvGDP_{jt} + \beta_3 \ln DifGDP_{pc_{jt}} + \beta_4 \ln AvGDP_{pc_{jt}}, + \beta_5 X^{k}_{j} + \varepsilon_{jkt},$$

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 $X^{k}_{j}$, 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 ($Nbflows^{k}_{jt}$) built as the number of products traded at the eight-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] Expected signs for explanatory variables are summarised in Table 2, the justification being as follows.

TABLE 2
Expected Signs for Explanatory Variables of VIIT

| *Log VIIT* | *New Trade Theory: Differences in Capital Intensities Break VIIT* | *Comparative Advantage: VIIT Driven by Differences in Capital Intensities* | *Neo-Ricardian and Neo-factorial Models: VIIT Driven by Technologies and Labour Qualities* |
|---|---|---|---|
| *DifCGDP* | (−) | (−) | (−) |
| *AvCGDP* | (+) | (+) | (+) |
| *DifCGDPpc* | (−) | (+) | |
| *AvCGDPpc* | (+) | (+) | |
| *Distance* | (−) | (−) | (−) |
| *Nbflows* | (+) | (+) | (+) |
| *Contiguity* | (+) | (+) | (+) |
| *Comlang* | (+) | (+) | (+) |
| *EU* | (+) | (+) | (+) |
| *Lagvol* | (+) | (+) | (+) |
| *DifPKpc* | | | (+) |
| *AvPKpc* | | | (+) |
| *DifTKpc* | | | (+) |
| *AvTKpc* | | | (+) |
| *DifHKpc* | | | (+) |
| *AvHKpc* | | | (+) |

[10] Variables denoted as *Distance, Contiguity* and *Comlang* are obtained from the dataset provided by Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). *Nbflows* taken from Eurostat Comext.

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 sizes of demand and in supply 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 $AvGDPpc_j$ to be 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 an extension of the internal market and local demand stimulates the innovation of products. Since consumers have a high preference for variety, 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 include *Distance*, *EU*, *Comlang* and *Contiguity*. Like any trade barriers, distance is supposed to reduce any kind of trade. We expect trading partners that maintain lower tariffs and non-tariff barriers, such as the EU members, to 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*), which 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 trade in general is controlled by *Lagvol*. These effects may differ from those they have on total trade because we do not know whether proximity fosters the exchange of products in different quality ranges. Furthermore, the corresponding coefficients are then similar to the ones we would obtain in a model where the dependent variable was 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 quality may be explained by differences in endowments and technologies, that is, by a specialisation 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 especially complex when partners differ strongly in their endowments and also because the nature of endowments plays an important role in specialisation in quality ranges. A positive sign for $DifGDPpc_j$ 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 highly 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 measured in per capita terms: investment in physical capital, R&D expenditure and education expenditure.[11] Model 3, which is our main contribution, incorporates the physical, technological and human capital stocks per capita that we have built. In Model 3 (respectively Model 2), we consider the differences between those stocks (respectively flows) with respect to Spain ($DifPKpc_j$, $DifTKpc_j$ and $DifHKpc_j$ for physical, technological and human capital, respectively) and the average level of these variables ($AvPKpc_j$, $AvTKpc_j$ and $AvHKpc_j$ for physical, technological and human capital, respectively). If the general version of the Heckscher–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, specialisation 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. We therefore need to determine under what conditions this proposal is valid.

## 5. ECONOMETRIC RESULTS

Our empirical results are divided into three parts. The first part is a test of the Heckscher–Ohlin, neo-Ricardian and neo-factorial explanations of vertical intra-industry trade flows among trade partners with different levels of

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

TABLE 3
OLS Estimations (1996–2000)

| *Log VIIT* | *Model 1*[a] | | *Model 1b*[a] | | *Model 2*[b] | | *Model 2b*[b] | | *Model 3*[c] | | *Model 3b*[c] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *DifCGDP* | −0.367*** | [0.031] | −0.171*** | [0.026] | −0.340*** | [0.032] | 0.160*** | [0.026] | 0.052 | [0.033] | 0.006 | [0.029] |
| *AvCGDP* | 2.304*** | [0.087] | 0.879*** | [0.080] | 2.102*** | [0.101] | 0.776*** | [0.089] | 0.202* | [0.109] | 0.102 | [0.096] |
| *DifCGDPpc* | −0.277*** | [0.042] | −0.151*** | [0.034] | | | | | | | | |
| *AvCGDPpc* | 1.092*** | [0.122] | 0.636*** | [0.099] | | | | | | | | |
| *Distance* | −0.867*** | [0.060] | −0.524*** | [0.049] | −0.797*** | [0.058] | −0.469*** | [0.048] | −0.980*** | [0.052] | −0.632*** | [0.048] |
| *Nbflows* | 0.004*** | [0.000] | 0.001*** | [0.000] | 0.004*** | [0.000] | 0.001*** | [0.000] | 0.002*** | [0.000] | 0.001*** | [0.000] |
| *Contiguity* | 0.696*** | [0.206] | 0.227 | [0.166] | 0.906*** | [0.216] | 0.325* | [0.175] | 0.479*** | [0.185] | 0.197 | [0.164] |
| *Comlang* | 1.121*** | [0.118] | 0.180* | [0.098] | 1.086*** | [0.117] | 0.157 | [0.098] | 0.490*** | [0.103] | 0.027 | [0.093] |
| *EU* | 1.260*** | [0.104] | 0.453*** | [0.086] | 1.251*** | [0.108] | 0.458*** | [0.090] | 0.819*** | [0.096] | 0.393*** | [0.086] |
| *Lagvol* | | | 0.924*** | [0.025] | | | 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* | | | | | −0.040 | [0.080] | 0.011 | [0.0651 | −0.467*** | [0.053] | −0.272*** | [0.047] |
| *AvTKpc* | | | | | −0.038 | [0.090] | 0.016 | [0.073] | 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] |
| *Intercept* | −42.341*** | [1.981] | −29.164*** | [1.636] | 696.8 | [1.587] | −280.2 | [1.280] | −28.68*** | [2.446] | −24.76*** | [2.158] |
| No. Obs. | 2,450 | | 2,450 | | 2,450 | | 2,450 | | 2,450 | | 2,450 | |
| *R*-Squared | 0.74 | | 0.83 | | 0.74 | | 0.83 | | 0.79 | | 0.84 | |

Notes:
Standard errors in brackets. ***, ** and * stand for statistical significance at the 1%, 5% and 10% levels, respectively.
a, b, c Endowments measured by *GDPpc*, flows and stocks, respectively.

development using OLS regressions. The second part provides a complementary empirical strategy to test whether the explanation differs among quantiles using QR techniques. The third part offers complementary estimations to test the robustness of the previous results by comparing OLS results for VIIT with OLS for inter-industry trade, total and horizontal intra-industry trade and vertical intra-industry trade in low and high quality ranges. We consider the 1996–2000 period and the same sample for all the estimations, which is the sample for which we have all the data concerning stocks.

### *a. OLS Regressions*

The outstanding feature of the estimation results reported in Table 3 is the robustness of the results, most of which are significant at the 1 per cent level. The overall *R*-squared ranges from 0.74 to 0.84, depending on the specifications. 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 other 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 are no longer significant (Models 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 highly significant, thus showing that trade costs have a specific influence on vertical intra-industry trade. This type of trade is especially important among EU partners (*EU* always has a positive and significant coefficient) while the impact of the other proxies for ties, like *Contiguity* and *Comlang*, are not so clear-cut since it is positive when the lag value is not included and non-significant in the other case.

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

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

harmony with the pure comparative advantage explanation of vertical intra-industry trade.[13]

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 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 found by Blanes and Martin (2000) for Spanish trade with the OECD and Díaz-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[14] than Milgram-Baleix and Moro-Egido (2005) due to the modifications we introduced. Our Model 1, here, is comparable to Model 2 presented in Milgram-Baleix 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 expenditure on 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-Baleix and Moro-Egido (2005), while here it is not.

### *b. Quantile Regressions*

Since we are interested in explaining vertical intra-industry trade among unequal partners by sectors, our sample is, by definition, heterogeneous. QR

[13] The same model was estimated for a larger sample of more that 5,000 observations without excluding countries for which we were not able to build stocks. Results for Models 1 and 1b were very similar.

[14] 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.

techniques allow us to check whether 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:

$$\ln VIIT_j^k = X_{jk}\beta_\theta + e_{\theta i} \quad \text{with } Quant_\theta(\ln VIIT_j^k | X_{jk}) = X_{jk}\beta_\theta,$$

where $X_{jk}$ is the vector of exogenous variables and $\beta_\theta$ is the vector of parameters. $Quant_\theta(\ln VIIT_j^k|X)$ denotes the $\theta$th conditional quantile of ln *VIIT* given *X*. Let us define the check function $\rho_\theta(z) = \theta z$ if $z \geq 0$ or $\rho_\theta(z) = (\theta - 1)z$ if $z < 0$. The $\theta$th regression quantile, $0 < \theta < 1$, is then defined as a solution to the problem:

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

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 its shape, then all the slope coefficients would be the same for all $\theta$.

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 3b are reported in Table 4.[15] 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 on the basis of the variance–covariance matrix of the coefficients of the system of quantile regressions. The tests are reported in Table 5. We plot the parameters estimated by QR techniques in Figures 2–4.

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

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

TABLE 4
QR Estimation (1996–2000)

| *Log VIIT* | *OLS* | | *Q10* | | *Q25* | | *Q50* | | *Q75* | | *Q90* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Model 1b* | | | | | | | | | | | | |
| *DifCGDP* | −0.171*** | [0.026] | −0.209*** | [0.034] | −0.169*** | [0.030] | −0.128 | [0.024] | −0.086*** | [0.027] | −0.082** | [0.038] |
| *AvCGDP* | 0.879*** | [0.080] | 0.887*** | [0.146] | 0.746*** | [0.096] | 0.615*** | [0.082] | 0.547*** | [0.071] | 0.445*** | [0.092] |
| *DifCGDPpc* | −0.151*** | [0.034] | −0.163* | [0.085] | −0.124** | [0.053] | −0.123*** | [0.032] | −0.079*** | [0.025] | −0.029 | [0.028] |
| *AvCGDPpc* | 0.636*** | [0.099] | 1.538*** | [0.260] | 1.079*** | [0.159] | 0.709*** | [0.113] | 0.401*** | [0.081] | 0.261*** | [0.083] |
| *Lagvol* | 0.924*** | [0.025] | 0.988*** | [0.068] | 1.016*** | [0.039] | 1.000*** | [0.034] | 0.970*** | [0.029] | 0.946*** | [0.035] |
| *Model 3b* | | | | | | | | | | | | |
| *DifCGDP* | 0.006 | [0.029] | −0.053 | [0.022] | −0.032 | [0.028] | 0.034 | [0.034] | 0.022 | [0.041] | 0.003 | [0.053] |
| *AvCGDP* | 0.102 | [0.096] | 0.147 | [0.117] | 0.082 | [0.082] | −0.068 | [0.115] | 0.038 | [0.125] | 0.074 | [0.238] |
| *DifPKpc* | −0.088*** | [0.029] | −0.070 | [0.066] | −0.016 | [0.042] | −0.071** | [0.035] | −0.041** | [0.020] | −0.015 | [0.031] |
| *AvPKpc* | 0.671*** | [0.199] | 0.834** | [0.337] | 0.828*** | [0.267] | 0.618*** | [0.227] | 0.271 | [0.178] | −0.225 | [0.266] |
| *DifTKpc* | −0.272*** | [0.047] | −0.348*** | [0.108] | −0.314*** | [0.069] | −0.298*** | [0.062] | −0.185*** | [0.049] | −0.076 | [0.071] |
| *AvTKpc* | 0.724*** | [0.100] | 1.102*** | [0.211] | 0.775*** | [0.144] | 0.785*** | [0.127] | 0.616*** | [0.097] | 0.562*** | [0.149] |
| *DifHKpc* | −0.069* | [0.037] | −0.300*** | [0.083] | −0.125* | [0.068] | −0.053 | [0.039] | 0.034 | [0.031] | 0.050 | [0.036] |
| *AvHKpc* | −0.750*** | [0.094] | −0.432* | [0.231] | −0.650*** | [0.162] | −0.779*** | [0.133] | −0.714*** | [0.099] | −0.486*** | [0.120] |
| *Lagvol* | 0.745*** | [0.028] | 0.811*** | [0.049] | 0.836*** | [0.039] | 0.775*** | [0.046] | 0.794*** | [0.042] | 0.825*** | [0.069] |

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

TABLE 5
Test for QR Estimations (1996–2000)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Model 1b* | | | | | | | | | | | |
| *DifCGDP* | Q25 | Q50 | Q75 | Q90 | All | *DifCGDPpc* | Q25 | Q50 | Q75 | Q90 | All |
| Q10 | 0.18 | 0.01 | 0.00 | 0.01 | 0.01 | Q10 | 0.59 | 0.63 | 0.33 | 0.13 | 0.10 |
| Q25 | | 0.08 | 0.01 | 0.03 | | Q25 | | 0.88 | 0.39 | 0.09 | |
| Q50 | | | 0.06 | 0.23 | | Q50 | | | 0.15 | 0.01 | |
| Q75 | | | | 0.92 | | Q75 | | | | 0.05 | |
| *AvCGDP* | Q25 | Q50 | Q75 | Q90 | All | *AvCGDPpc* | Q25 | Q50 | Q75 | Q90 | All |
| Q10 | 0.28 | 0.05 | 0.02 | 0.01 | 0.07 | Q10 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Q25 | | 0.10 | 0.05 | 0.02 | | Q25 | | 0.01 | 0.00 | 0.00 | |
| Q50 | | | 0.38 | 0.13 | | Q50 | | | 0.00 | 0.00 | |
| Q75 | | | | 0.21 | | Q75 | | | | 0.08 | |
| *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 | |

per capita are negative and significantly different from zero. Additionally, as shown in Figure 2, 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 (Table 5). 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 Figures 3 and 4. 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

FIGURE 2
OLS and QR Estimated Coefficients in Model 1b

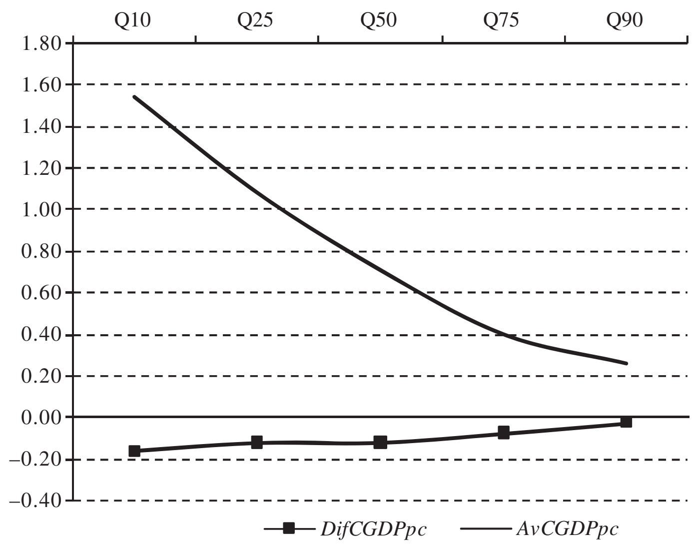
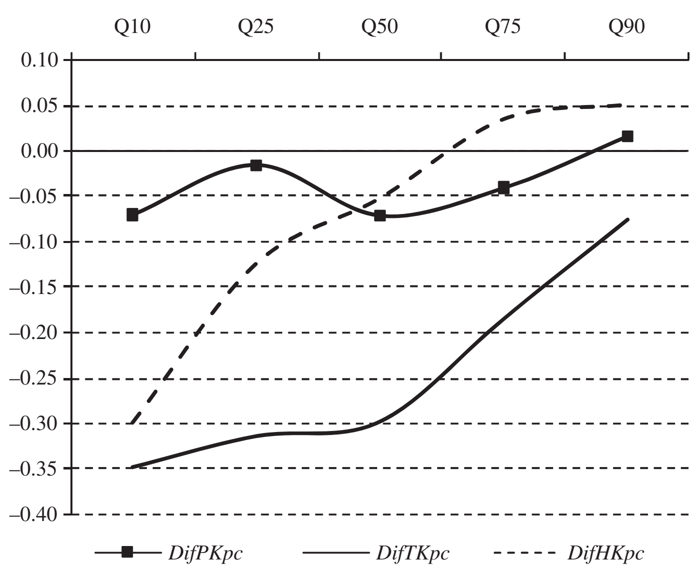
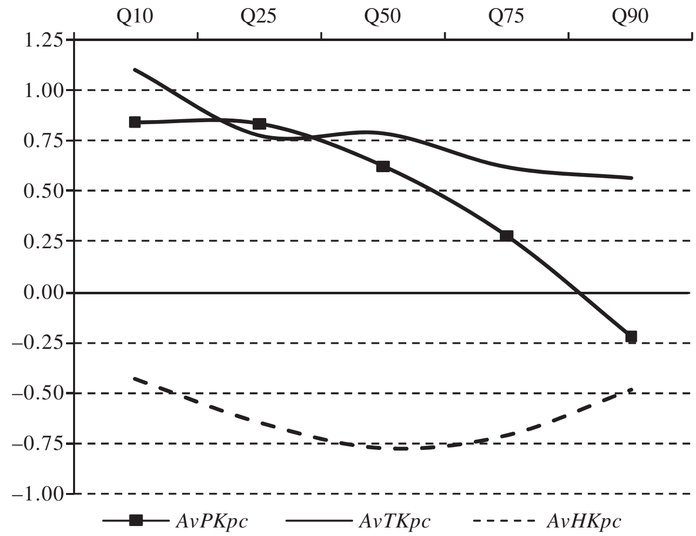



FIGURE 3
OLS and QR Estimated Coefficients in Model 3b




larger in absolute terms for low levels of vertical intra-industry trade. The pair-wise tests and *F*-test statistics confirm that differences among quantiles are significant. In particular, the upper tail behaves differently from the rest. The

FIGURE 4
OLS and QR Estimated Coefficients in Model 3b



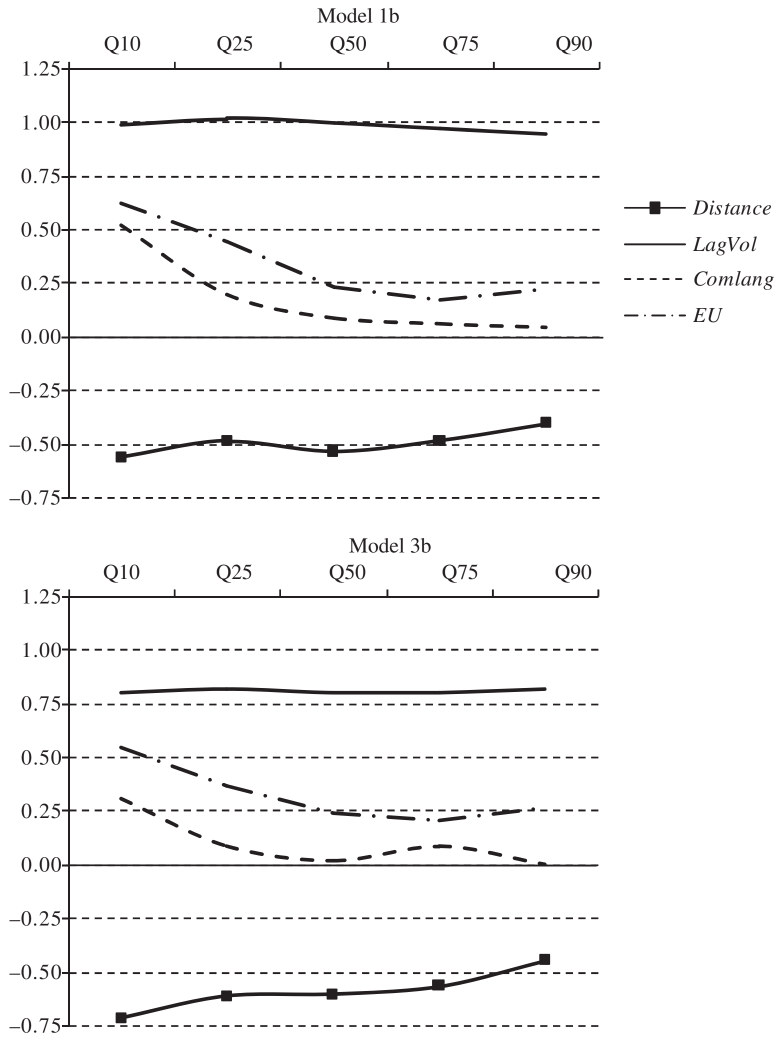

estimated effect ranges from −0.348 in the 0.10th quantile to −0.076 in the 0.90th quantile. In the case of differences in human capital stocks per capita, *DifHKpc*, the effect is negative and significant only for the three lower quantiles. A difference in capital intensity is only an impediment for 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. In consequence, vertical intra-industry trade with emerging countries that grow quickly could rapidly increase this type of flow. The overall test and pairwise tests confirm that these differences along quantiles are significantly different from zero.

Figure 5 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

FIGURE 5
OLS and QR Estimated Coefficients of Gravity Equation Variables, Model 1b




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 quantiles, while *Distance* only matters for these higher 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.

### c. *Complementary Results*

Our previous models and conclusions are based on the expected signs concerning the impact of the difference in endowments on vertical intra-industry trade according to alternative theoretical explanations of vertical intra-industry trade. The earliest theories did not distinguish between horizontal intra-industry trade and vertical intra-industry trade so determinants of vertical intra-industry trade are expected to be rather similar to that of intra-industry trade. Theories that consider that the distinction between horizontal intra-industry trade and vertical intra-industry trade plays an important role suggest that vertical intra-industry trade may be driven by a comparative explanation similar to inter-industry trade where differences in capital intensities are the source of specialisation. Finally, the neo-Ricardian and neo-factorial explanations pointed out the importance of the nature of endowments that may play an important role in quality trade and inter-industry trade. Here, we propose a more general verification of these theoretical predictions by comparing the results of Models 1b and 3b for all four types of trade: inter-industry trade, intra-industry trade, horizontal intra-industry trade and vertical intra-industry trade. In particular, we test whether differences in endowments have a different impact on the different types of trade as predicted by the above-mentioned theories. Estimation results are reported in Tables 6 and 7.

Our models fit better for vertical intra-industry trade than for horizontal intra-industry trade. This may be due to the fact that horizontal intra-industry trade is specific to some products or industries and we do not have many variables of an industry dimension. Differences in GDP per capita have a significant negative effect on both types of intra-industry trade. When the nature of endowments is taken into account technological differences also reduce both types of intra-industry trade, while differences in physical and human capital do not matter for horizontal intra-industry trade. In the same way, the impact of market sizes, *Lagvol*, *Distance*, *Contiguity* and *EU* dummy are higher for horizontal intra-industry trade. Overall, our results confirm the hypothesis that quality differentiation must be influenced by the nature of endowments while horizontal differentiation is better explained by proximities of demand. Concerning the overall intra-industry trade, determinants are rather similar to those obtained for vertical intra-industry trade (except for *Contiguity*) which is clearly explained by the fact that vertical intra-industry trade represents more than two-thirds of intra-industry trade.

Concerning the results for inter-industry trade, determinants are clearly different from those of intra-industry trade, in particular concerning the proxies

TABLE 6
OLS Estimation (1996–2000) of VIIT, HIIT, IIT and Inter

| | *Log VIIT* | | *Log HIIT* | | *Log IIT* | | *Log Inter* | |
|---|---|---|---|---|---|---|---|---|
| | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* |
| *DifCGDP* | −0.0171*** | 0.006 | −0.062* | 0.027 | −0.142*** | 0.039 | −0.029** | −0.003 |
| | [0.026] | [0.029] | [0.034] | [0.041] | [0.026] | [0.029] | [0.012] | [0.014] |
| *AvCGDP* | 0.879*** | 0.102 | 0.830*** | 0.350** | 0.798*** | 0.018 | 0.150*** | 0.068 |
| | [0.080] | [0.096] | [0.108] | [0.140] | [0.080] | [0.096] | [0.036] | [0.046] |
| *DifCGDPpc* | −0.151*** | | −0.192*** | | −0.184*** | | −0.021 | |
| | [0.034] | | [0.046] | | [0.035] | | [0.016] | |
| *AvCGDPpc* | 0.636*** | | 0.114 | | 0.638*** | | 0.092** | |
| | [0.099] | | [0.131] | | [0.099] | | [0.046] | |
| *Distance* | −0.0524*** | −0.632*** | −0.805*** | −0.800*** | −0.567*** | −0.662*** | −0.047** | −0.067*** |
| | [0.049] | [0.048] | [0.066] | [0.067] | [0.049] | [0.048] | [0.023] | [0.022] |
| *Nbflows* | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.000*** | 0.000*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| *Contiguity* | 0.227 | 0.197 | 0.709*** | 0.705*** | 0.339** | 0.332** | −0.179** | −0.160* |
| | [0.166] | [0.164] | [0.208] | [0.210] | [0.168] | [0.165] | [0.082] | [0.083] |
| *Comlang* | 0.180* | 0.027 | 0.313** | 0.202 | 0.126 | −0.048 | 0.129*** | 0.116*** |
| | [0.098] | [0.093] | [0.139] | [0.136] | [0.098] | [0.092] | [0.044] | [0.043] |

TABLE 6
*Continued*

| | *Log VIIT* | | *Log HIIT* | | *Log IIT* | | *Log Inter* | |
|---|---|---|---|---|---|---|---|---|
| | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* |
| *EU* | 0.453*** | 0.393*** | 0.746*** | 0.768*** | 0.516*** | 0.466*** | 0.026 | −0.005 |
| | [0.086] | [0.086] | [0.113] | [0.116] | [0.087] | [0.087] | [0.041] | [0.042] |
| *Lagvol* | 0.924*** | 0.745*** | 0.958*** | 0.876*** | 0.981*** | 0.803*** | 0.853*** | 0.836*** |
| | [0.025] | [0.028] | [0.040] | [0.046] | [0.025] | [0.028] | [0.009] | [0.010] |
| *DifPKpc* | | −0.088*** | | −0.077* | | −0.089*** | | −0.027* |
| | | [0.029] | | [0.040] | | [0.030] | | [0.014] |
| *AvPKpC* | | 0.671*** | | −0.401 | | 0.676*** | | 0.364*** |
| | | [0.199] | | [0.276] | | [0.199] | | [0.086] |
| *DifTKpc* | | −0.272*** | | −0.191*** | | −0.352*** | | −0.045** |
| | | [0.047] | | [0.069] | | [0.047] | | [0.023] |
| *AvTKpc* | | 0.724*** | | 0.682*** | | 0.771*** | | −0.044 |
| | | [0.100] | | [0.147] | | [0.100] | | [0.042] |
| *DifHKpc* | | −0.069* | | 0.038 | | −0.064* | | −0.015 |
| | | [0.037] | | [0.050] | | [0.037] | | [0.018] |
| *AvHKpc* | | −0.750*** | | −0.475*** | | −0.763*** | | −0.082* |
| | | [0.094] | | [0.139] | | [0.094] | | [0.042] |
| *Intercept* | −29.16*** | −24.76*** | −24.13*** | −17.30*** | −27.82*** | −23.68*** | −5.37*** | −69.45*** |
| | [1.636] | [2.158] | [2.121] | [2.917] | [1.648] | [2.174] | [0.780] | [1.015] |
| No. Obs. | 2,450 | 2,450 | 2,079 | 2,079 | 2,502 | 2,502 | 2,895 | 2,895 |
| *R*-Squared | 0.83 | 0.84 | 0.75 | 0.75 | 0.84 | 0.85 | 0.92 | 0.93 |

Notes:
Standard errors in brackets. ***, ** and * stand for significance at the 1%, 5% and 10% levels, respectively.

TABLE 7
OLS Estimation (1996–2000) of VIIT, VIIT High, VIIT Low, HIIT, IIT and Inter without Differences

| | *Log VIIT* | | *Log VIIT high* | | *Log VIIT low* | | *Log HIIT* | | *Log IIT* | | *Log Inter* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* | *Model 1b* | *Model 3b* |
| *CGDP* | 0.647*** | 0.647*** | 0.592*** | 0.507*** | 0.590*** | 0.681*** | 0.428*** | 0.383*** | 0.617*** | 0.620*** | 0.129*** | 0.139*** |
| | [0.035] | [0.032] | [0.043] | [0.040] | [0.042] | [0.039] | [0.052] | [0.047] | [0.035] | [0.032] | [0.015] | [0.014] |
| *GDPpc* | 0.053 | | −0.232*** | | 0.369*** | | −0.081 | | 0.070* | | 0.041** | |
| | [0.038] | | [0.046] | | [0.046] | | [0.055] | | [0.038] | | [0.016] | |
| *Distance* | −0.722*** | −0.731*** | −0.618*** | −0.581*** | −0,786*** | −0.850*** | −0.853*** | −0.828*** | −0.756*** | −0.764*** | −0.115*** | −0.124*** |
| | [0.046] | [0.047] | [0.058] | [0.059] | [0.056] | [0.057] | [0.067] | [0.069] | [0.046] | [0.047] | [0.022] | [0.022] |
| *Nbflows* | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.000*** | 0.000*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| *Contiguity* | 0.302* | 0.277* | 0.514*** | 0.610*** | 0.385** | 0.245 | 0.798*** | 0.856*** | 0.427*** | 0.400** | 0.143* | 0.168** |
| | [0.158] | [0.158] | [0.184] | [0.185] | [0.184] | [0.184] | [0.207] | [0.207] | [0.160] | [0.159] | [0.080] | [0.079] |
| *Comlang* | 0.151* | 0.280*** | −0.140 | −0.022 | 0.400*** | 0.451*** | 0.086 | 0.193 | 0.109 | 0.240** | 0.193*** | 0.244*** |
| | [0.086] | [0.098] | [0.106] | [0.122] | [0.105] | [0.119] | [0.127] | [0.146] | [0.086] | [0.098] | [0.039] | [0.043] |
| *EU* | 0.419*** | 0.436*** | 0.643*** | 0.541*** | 0.387*** | 0.507*** | 0.655*** | 0.631*** | 0.490*** | 0.520*** | −0.017 | −0.009 |
| | [0,081] | [0.078] | [0.096] | [0.093] | [0.096] | [0.093] | [0.110] | [0.107] | [0.081] | [0.078] | [0.039] | [0.038] |
| *Lagvol* | 0.683*** | 0.676*** | 0.680*** | 0.695*** | 0.645*** | 0.614*** | 0.857*** | 0.854*** | 0.738*** | 0.728*** | 0.788*** | 0.785*** |
| | [0.029] | [0.029] | [0.038] | [0.038] | [0.036] | [0.036] | [0.047] | [0.047] | [0.029] | [0.029] | [0.011] | [0.011] |
| *PKpc* | | −0.018*** | | −0.024*** | | 0.002 | | −0.032*** | | −0.024*** | | 0.005** |
| | | [0.006] | | [0.008] | | [0.008] | | [0.009] | | [0.006] | | [0.002] |
| *TKpc* | | 0.025*** | | 0.021** | | 0.030*** | | 0.047*** | | 0.033*** | | −0.005 |
| | | [0.009] | | [0.010] | | [0.010] | | [0.012] | | [0.009] | | [0.003] |
| *HKpc* | | 0.673** | | −0.494 | | 1.589*** | | −0.180 | | 0.683** | | 0.473*** |
| | | [0.292] | | [0.368] | | [0.356] | | [0.444] | | [0.291] | | [0.118] |
| *Intercept* | −15.387*** | −16.179*** | −7.925*** | −7.354*** | −11.477*** | −13.026*** | −11.653*** | −10.953*** | −15.026*** | −15.739*** | −3.027*** | −3.844*** |
| | [0.568] | [0.773] | [0.725] | [0.995] | [0.708] | [0.959] | [0.858] | [1.199] | [0.565] | [0.769] | [0.228] | [0.293] |
| No. Obs. | 2,450 | 2,450 | 2,267 | 2,267 | 2,305 | 2,305 | 2,079 | 2,079 | 2,502 | 2,502 | 2,895 | 2,895 |
| *R*-squared | 0.83 | 0.84 | 0.77 | 0.77 | 0.81 | 0.81 | 0.75 | 0.75 | 0.85 | 0.85 | 0.93 | 0.93 |

Notes:
Standard errors in brackets. ***, ** and * stand for significance at the 1%, 5% and 10% levels, respectively.

for trading costs: *Distance* has a very small negative effect; *Nflows*'s coefficient is null and significant, as expected; *EU* has no significant effect and inter-industry trade with Latin America is larger than predicted by the other variables. Concerning the size of the markets or levels of endowments per capita, they influence inter-industry trade in the same way as intra-industry trade, though the impacts are lower. The only exception is the level of technological capital that does not matter for inter-industry trade. Finally, differences in GDP per capita do not display the expected positive sign but the coefficient is non-significant as opposed to all types of intra-industry trade. Differences in technological and physical capital stocks have a negative effect but this is slighter than for intra-industry trade and less significant, and the impact of the differences in human capital is not significant. In sum, differences among partners do not enhance inter-industry trade but do not prevent it as much as intra-industry trade. Therefore, our results concerning vertical intra-industry trade with OLS are different from that obtained for inter-industry trade but we confirm that the determinants of vertical intra-industry trade for the highest quantiles in the previous section are similar to those obtained for inter-industry trade.

We expect Spanish exports to be of higher quality than their imported counterparts when the trading partners have a higher level of GDP or physical, technical and human capital per capita. The distinction between high and low quality vertical intra-industry trade therefore sheds some important light on our previous results. Unlike the whole bilateral vertical flows, it makes no sense to explain high and low vertical intra-industry trade in terms of the absolute value of the difference in endowments. We estimate two models for each type of trade with the same basic explanatory variables as in Models 1b and 3b but where the average levels and differences of GDP, GDP per capita or endowments per capita are substituted by the levels of the corresponding variables for the trading partner.

The higher the GDP per capita of the partner, the higher are both inter- and intra-industry trade. When we disentangle vertical intra-industry trade into low and high export unit values, we find, as expected, that the quality of exports compared to imports is lower, the richer are the inhabitants of the trading partner. Once other variables are controlled for, the quality of Spanish exports to Hispanic countries is lower than that of imports. It is confirmed that the level of physical capital per capita is not a key determinant of any kind of trade, while the higher the level of technological capital of the partner, the higher the level of any kind of intra-industry trade and the lower the level of inter-industry trade. Regarding the level of human capital, the results are in harmony with the results for GDP per capita in Model 1b: inter-industry trade is higher with countries with low human capital, i.e. the purchasing power effect dominates over the effect of specialisation. These results are in harmony with the study made by Ray (1991) of the United States intra-industry trade, which tends to show that these flows consist of intermediate goods produced by small plants using non-standardised techniques. In this line, and to the extent that this type of 'made-to-order' type of production is intensive in qualified labour, it is not surprising to find that the capital to labour ratio has a non-significant impact while the human capital per capita positively influences vertical intra-industry trade.

Turning to the difference between qualities, the level of human capital per capita of the trading partners enhances Spanish exports of low quality while it has no significant impact on high quality exports. Our results are in line with the study made by Martín and Orts (2002) of Spanish vertical intra-industry trade with the EU during the 1988–92 period. That is, Spain is still importing technology-intensive goods and specialising in low quality products that are intensive in physical capital.

## 6. 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 are decisive for any kind of intra-industry trade. On the other hand, Spain's vertical intra-industry trade in low quality trends and inter-industry trade are higher, the higher the qualification of labour or the richer are the inhabitants of the trading partner. The use of QR techniques leads us to accept a more reduced version of the comparative advantage explanation that applies to large flows of vertical differentiated products (typically flows among rich countries). We show that the impact of differences in endowment decreases in absolute value as the 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 Heckscher–Ohlin explanation of vertical intra-industry trade.

Our results provide interesting insights for Spain and emerging countries. A large part of Spanish trade already takes place on an inter-industry basis or consists of exporting low quality products in exchange for similar products in a higher quality range, in particular to European countries. Our study confirms that the composition of Spanish trade is not yet similar to that of the richer countries and that this country still bases its competitiveness mainly on low prices in terms of its sales to richer countries. To a lesser extent and more surprisingly, this is also true for its trade with emerging countries and our study confirms that a minimum level of similarities of living standard and technological capital is needed to enhance vertical intra-industry trade or intra-industry trade in general. A promising line of research concerns empirical methods and studies of precise sectors to understand better the role played by outward processing in intra-industry trade and the link with outward foreign direct investment. If low quality exports to emerging countries are those mainly involved in outward processes, then the increase in low quality Spanish exports would not seem to be such bad news and the interpretation of our results would be more optimistic for Spanish trade patterns.

Finally, our study provides important lessons for emerging and developing countries. Our study shows that a minimum level of technological capital and also human capital is necessary to integrate in the international division of production since the trade in vertically differentiated goods is more intensive in human and technological capital than in physical capital.

## APPENDIX

Following Greenaway and Milner (1983), we define the volume of intra-industry trade (*IIT*) between Spain and country $j$ for each eight-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:[16]

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

[16] There are several problems concerning this method, as pointed out by several authors such as Nielsen and Lüthje (2002). First, the choice of the margin is not neutral as confirmed by the fact that some products are classified in horizontal or vertical categories depending on the year. Second, it is clear that the choice of the level of aggregation for the product definition matters. It should not be too high or IIT will be overestimated. On the other hand, a high level of disaggregation could underestimate VIIT because similar products are considered different. Since there is no straightforward answer to this empirical problem, we choose, like other studies, the eight-digit level to disentangle vertical and horizontal intra-industry trade.

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 and Frendenberg (1997) use this methodology to differentiate between vertical and horizontal intra-industry trade. Therefore, if the export and import unit values differ less than ±α per cent, 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 vertically-differentiated products (*VIIT*) and intra-industry trade of horizontally differentiated products (*HIIT*) are obtained as follows:

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

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 per cent is used, vertical intra-industry trade volume is correlated at 99 per cent with the measure of vertical intra-industry trade when a margin of 25 per cent is used. We checked that the choice of one of these two values for α, though arbitrary, did not have any substantial effect on the results of the estimations. Hence, we used a margin of 25 per cent.

This method also makes it possible to disentangle vertical intra-industry trade into quality ranges. When the unit export value is higher than the unit import value for a product by more than 25 per cent, then we classify this two-way trade in the high quality range (defined from the domestic perspective). In the same way, a product whose unit export value represents less than 75 per cent of the unit value of its import counterpart is considered to be low quality trade.

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