VERTICAL SPECIALIZATION AND INTRA-INDUSTRY TRADE: THE ROLE OF FACTOR ENDOWMENTS.*

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ABSTRACT

In this paper, we rely on vertical differentiation models (Falvey-Kierzkowski type) to study the effects of differences in factor endowments on vertical intra-industry specialization. These effects can vary depending on the relative position of each country in terms of both its specialization in high or low qualities and its technological (dis)advantage. We focus on the Spanish intra-industry trade with the main OECD countries. This allows us to consider the case of an intermediate country, as Spain basically exports low-quality varieties to the Northern countries of the OECD and high-quality varieties to the Southern ones. In order to achieve more general results, we consider different types of productive factors: physical, human and technological capital.

Keywords: vertical differentiation, intra-industry trade, factor endowments.
JEL codes: F12, F14

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I. INTRODUCTION

One of the topics in international trade that has received more attention in the last years refers to the distinction between different types of intra-industry trade, depending on the type of product differentiation prevailing in each industry. Thus, if the varieties produced in one industry are of horizontal type (in other words, the quality of all the varieties that are being exchanged is the same), the usual conclusions about the role of factor endowments and scale economies that stem from the monopolistic competition framework can be accepted. However, empirical research has showed that most intra-industry trade is of a vertical type, involving exchange of varieties that belong to different levels of quality. In this case, it is usually assumed that the level of quality is positively associated with the intensity of capital used in the production. The main theoretical explanations, that came out in the late eighties, state that the intra-industry trade pattern of specialization is similar to the inter-industry (factor endowment based) trade, as long as comparative advantage is relevant to explain not only the share of intra-industry trade but also the intra-industry specialization.

The framework defined by these models (usually labelled as vertical differentiation models) has led to think about some of the most widely accepted conclusions in the intra-industry trade literature, mainly those related to the adjustment costs of trade. It has been traditionally argued that in those cases in which intra-industry flows predominate, higher degrees of openess in the economies should not imply great adjustment costs, as long as the likely changes in the allocation of endowments take place inside the different industries. This also means that the factor proportions employed in each industry should not change substantially. However, this could not happen in the case of vertical differentiation, given that specialization in different varieties means that different productive processes (and, therefore, different factor proportions) are being used for each variety. Accordingly, more trade means that excesses of demand of different sign will appear in the factor markets and, therefore, the capital/labour ratios will change.

The opposite predictions concerning the costs of trade that stem from the different intra-industry trade patterns explain the interest recently raised in this area of research. In this sense, it is not a coincidence that most of empirical studies devoted to the study of vertical and horizontal patterns in intra-industry trade are referred to Europe[1] and, more recently, to the intra-industry trade

[1] See Greenaway, Hine and Milner (1994, 1995), Torstensson (1996) and, more recently, Blanes and Martin (2000).

between the EU and the Central and East European Countries (CEECs).[2] In the last years, the basic discussion about the enlargement of the EU has been referred to the CEECs which, in a sense, represent the economic South in Europe, whereas the North would be represented, in general terms, by the current EU countries.

In this paper, we study the Spanish intra-industry specialization in vertically differentiated goods with respect to some OECD countries. The paper is organized as follows: first, we summarize the basic theoretical items and the empirical implications to be tested. The next two sections are devoted to define the set of explanatory variables and the econometric specification. In the following section, the results achieved for the traditional Grubel-Lloyd index are discussed. Next, we introduce an alternative approach to analyze vertical intra-industry specialization and factor endowments; to do this, we first characterize the Spanish vertical intra-industry trade specialization with regard to OECD countries. Finally, some concluding remarks are presented.

II. THEORETICAL EXPLANATIONS OF VERTICAL INTRA-INDUSTRY TRADE AND THE BASIC EMPIRICAL IMPLICATIONS.

The theoretical models for vertical intra-industry trade overcome the traditional indeterminate pattern of intra-industry trade in terms of which varieties are produced by each country. To do this, a pattern based on differences in technology and factor endowments is introduced. The models by Falvey and Kierzkowski (1987) jointly with Flam and Helpman (1987) represent the theoretical foundation to explain why one country enjoys comparative advantage in the production of varieties belonging to certain levels of quality. The framework developed in both models is similar in several aspects: a vertically differentiated good is produced in two countries, one of them enjoying comparative advantage in the higher-quality varieties, whereas the other one specializes in the lower range of qualities. Inequalities in income distribution ensure that both countries will demand all the available qualities. In this context, intra-industry trade appears, although not in the same way as predicted by the monopolistic competition models.

In Falvey and Kierzkowski (1987), technology differences (labour productivity) across countries set the pattern for intra-industry trade; they prevent free trade from leading to international factor price equalization. Besides, high (low) quality varieties are assumed to be relatively capital

[2] See Aturupane, Djankov and Hoekman (1999).

(labour) intensive. Under these two assumptions, the most technologically advanced country (with higher wages) will have comparative advantage in the higher-quality set of varieties, as capital is relatively cheaper there. Simmetrically, the low-wage country will enjoy the comparative advantage in the low-quality varieties.[3]

In general, differences in relative endowments between countries will imply differences in their relative factor price which, consequently, affect comparative advantages. In the context of the model, the pattern of specialization of each trade partner is crucial to determine the way changes in comparative advantages affect trade flows. When the country which enjoys a higher capital/labour ratio is the high quality exporter, two different effects take place. On the one hand, increasing differences in factor endowments mean that the number of qualities in which this country has comparative advantage increases. On the other hand, its demand for low-quality varieties lowers (as country s average income is higher), whereas the low quality exporter (which have a lower capital/labour ratio) relative average income is lower, reducing its demand for high-quality varieties produced abroad. All these effects together tend to reduce the volume of intra-industry trade between the two countries; in other words, higher differences in relative factor endowments are associated with lower levels of intra-industry trade through their effects on income per capita.

The model does not take into account the case in which the most technologically advanced and/or the capital/labour abundant country is the exporter of low-quality varieties, or vice versa. However, despite this pattern of trade being less evident than that stated above, both of them are usually found together in empirical studies regarding intra-industry trade.[4] Does the Falvey-Kierzkowski model provide any guide to explain this second type of trade flows? It certainly does not fit very well in the model s structure, but we can take as a basis the same type of reasoning as above. Thus, increasing differences in factor endowments should imply that the number of qualitites in which the low-quality exporter enjoys comparative advantage increases; besides, the demand of varieties produced abroad is increasingly larger in both partner countries because of

[3] In the model by Flam and Helpman (1987), differences in technology are also a key feature in determining the intra-industry pattern of qualitites between countries. These authors achieve very similar results to those of Falvey and Kierzkowski in a framework with only one productive factor (labour), whereas differences in productivity remain. In this case, any change which tends to increase (lessen) the range of qualities in which the less advanced country has comparative advantage increases (reduces) intra-industry trade. These changes can be referred to the technological level (in terms of labour productivity) or to the labour endowments of each country.

[4] See Greenaway, Hine and Milner (1994) or Blanes and Martín (2000), for instance.

the higher income in the low-quality importer and the lower income in the high-quality importer.[5] Therefore, in this case, vertical intra-industry trade could increase depending on bilateral differences. Summarizing, the effect of increasing bilateral differences in factor endowments on vertical intra-industry trade depends on the *variety specialization* in each good of the country which is relatively better endowed.

The main conclusions of the model may be summed up as follows:

(a) Countries exchange vertically differentiated products. They engage into trade from asymmetric positions which are caused by both differences in technology and their factor endowments. These differences explain the existence of intra-industry trade (as long as they are not strong enough to lead countries to complete specialization in production): the more technologically advanced country has comparative advantage in the varieties of high quality, whereas the less productive country will specialize in the low-quality varieties.

(b) There is demand for all the available varieties because income is unequally distributed in each country, so that consumers with lower income will demand low-quality varieties and high-income consumers will demand the best qualities, regardless of their country of origin.

(c) Increasing bilateral differences in relative factor endowments will decrease bilateral intra-industry trade shares between countries because of their effect on income per capita; changes in productivity differences (understood as changes in technology) would have similar effects.

The scheme described above has sustained most empirical research on vertical intra-industry trade. This body of work takes the usual Grubel-Lloyd measure of vertical intra-industry trade as the variable to be explained. In the following section, we describe both the construction of the explanatory variables and justify our econometric specification.

[5] To achieve this results, however, several assumptions must be made in relation to the secondary effects that changes in relative endowments have on income distributions in both countries.

III. VARIABLES AND ECONOMETRIC SPECIFICATION

III.1 Dependent variable

We measure the share of vertical intra-industry trade between Spain and several OECD countries by the adjusted Grubel-Lloyd index. Our sample encompasses trade in 76 industries from the Spanish *Encuesta Industrial* during the period 1988-1992. We have employed data of exports and imports up to an eight-digit level in product categories in the Brussels Tariff Classification obtained from the EUROSTAT database. The entries were regrouped later in order to accommodate them to the taxonomy used by the Spanish *Encuesta Industrial*, based on the National Classification of Economic Activities. The OECD countries included in the sample are France, Belgium-Luxembourg, the Netherlands, Germany, Italy, the United Kingdom, Ireland, Denmark, Greece, Portugal, Norway, Sweden, Finland, Switzerland, Austria, Japan, Canada, the United States, Australia and New Zealand.

In order to consider only trade flows in vertically differentiated products, we follow the Abd-el-Rahman (1991) method.[6] This mechanism compares export and import unit values for each product accroding to the following expression:

$$\frac{UVM_{ijm}}{UVX_{ijm}} \leq 1-a \quad \text{or} \quad \frac{UVM_{ijm}}{UVX_{ijm}} \geq 1+a$$

where UVM_{ijm} and UVX_{ijm} are the import and export unit values (respectively) for Spanish trade with country *m* in variety *i* produced in industry *j*. If the ratio of unit values exceeds the limits of the interval $[1-\alpha, 1+\alpha]$, we consider the exchange in these varieties as vertical trade, and horizontal otherwise. As it is usual in the literature, the value for α has been fixed at 15%.

The trade that is measured by the vertical term of the Grubel-Lloyd index comprises two radically different patterns. Firstly, if the ratio is higher than $1+\alpha$, then we can interpret that the quality of our exports is higher than that of the imported varieties, so that vertical trade is labelled as *high-quality*. Secondly, if the ratio is lower than $1-\alpha$, then we face *low-quality* vertical intra-industry trade. Thus, the usual Grubel-Lloyd index contains the following components:

$$IIT_{jm} = HIIT_{jm} + VIIT_{jm} = HIIT_{jm} + (VIIT_{jm}^{LQ} + VIIT_{jm}^{HQ})$$

where IIT_{jm} is the adjusted Grubel-Lloyd index for total intra-industry trade in industry *j* with country *m*, $HIIT_{jm}$ and $VIIT_{jm}$ stand for its horizontal and vertical components, and the superscripts refer to the exports being low or high-quality varieties (*LQ* and *HQ*, respectively). The former component is the most important one in the Spanish vertical intra-industry trade, as showed by Gordo and Martín (1996).[7] In the rest of this paper, we forget the horizontal term of the Grubel-Lloyd index and will focus just on vertical intra-industry trade. This means that we keep aproximately 80% of Spanish intra-industry trade with the OECD countries.

III.2 Explanatory variables.

The aim of this paper is to determine the relation between intra-industry trade patterns and factor endowments. Therefore, the set of variables will mainly focus on the supply side. We include direct measures of factor endowments.[8] Three different types of factors of production have been considered: physical, technological and human capital. Accordingly, we will define three indicators. The corresponding indicators are the following ones:

KLDIF Bilateral inequality in physical capital per worker endowment[9]

RDDIF Bilateral inequality in technological capital stock per worker[10]

HUMKDIF Bilateral inequality in human capital indicator (mean years of schooling) [11]

In Figures I to III, indices for each measure of factor endowment and country are displayed. In all cases, Spain takes value unity and the rest of countries in the sample are computed in comparison to this value. The structure observed is not quite surprising: whereas in terms of the indicator of human capital, Spain is located in the upper half of the sample, it is at its bottom in

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6 It is also employed in Greenaway, Hine and Milner (1994, 1995) or Blanes and Martín (2000), among others.

7 Blanes and Martín (2000) tone down this evidence. They distinguish Spanish vertical intra-industry trade with OECD countries on the one hand, and with non-OECD countries on the other hand. In the first case, trade flows are mostly characterized by Spanish exports being low-quality, whereas the opposite pattern holds for the vertical trade with the non-OECD countries.

8 Greenaway, Hine and Milner (1994) try to capture the effect of differences in factor endowments through differences in per capita income, whereas Greenaway, Milner and Elliot (1996) use alternatively differences in per capita income and a direct indicator of differences in capital per worker.

9 Data have been obtained from Summers and Heston (1991) Penn World Tables.

10 An indicator of technological stock has been built following Coe and Helpman (1995) procedure. Data come from OECD s *Basic Science and Technology Statistics*.

11 Data obtained from De la Fuente and Doménech (2000) revised version of Barro and Lee (1996) data set for OECD countries.

terms of physical or technological capital per worker. This is coherent with the low levels of expenditure in R&D that characterizes the Spanish economy,[12] which is a traditional importer of technology. However, its relatively high endowment of qualified labour allows Spain to fully exploit these imported technologies. The sign expected for all these indicators in most of the empirical research on vertical intra-industry trade between the Grubel-Lloyd index and differences in factor endowments is positive, although it could also be negative, as explained in the previous section. Given that we distinguish two different situations regarding vertical intra-industry trade flows in each sector (as measured by $VIIT^{LQ}$ and $VIIT^{HQ}$), the same differences should imply different effects on each index.

[FIGURE I]

[FIGURE II]

[FIGURE III]

Differences in per capita income have also been employed in order to incorporate differences in factor endowments or technology into the analysis.[13] In the context of the Falvey and Kierzkowski model there are strong arguments for this latter option, as most of the theoretic effects of changes in relative factor endowments are studied through their translation into relative changes in income per capita. Thus, we also include differences in per capita income alternatively to the three indicators above. Therefore, the sign expected is the same as in the previous variables.

INCDIF: Bilateral inequality in per capita GDP

Anyway, it is possible that this variable also measures differences in preferences, according to the well-knonw Linder hypothesis. In order to isolate the effect from the demand side, we include in the analysis two indicators directly related to the effect of income:

INCOM: Arithmetic mean of per capita GDPs of Spain and each OECD country

INCDIS: Gini index of income distribution in the OECD countries

[12] At least, in the period comprised in the sample.

[13] See Greenaway, Hine and Milner (1994).

This indicators measure both the effect of the level of income and its distribution. [14] A higher level of income should favour the aggregate demand for differentiated production, regardless of the quality each consumer can afford. Furthermore, the more distributed the income, the higher the share of intra-industry trade should be, regardless of the type of varieties exchanged. Thus, a positive sign is expected for INCOM and a negative sign for INCDIS. Finally, a dummy variable **UE** to pick the effect of the partner country belonging to the European Union[15] has also been included as a regressor. As integration processes are suposed to promote trade flows, a positive effect is expected for this variable. We do not expect different results for the three Grubel-Lloyd indices in the case of these three variables.

Finally, some sector variables have been included in order to measure industry characteristics which will help to explain inter-sectoral variability of the values of the index. The industry variables employed in the analysis are the following ones.

RDSALES R&D expenditure as a percentage of sales
KHUM Human capital intensity in the industry[16]
HERF Herfindahl index of industry concentration

The two first variables capture the importance of research expenditure and qualification of labour in a context where product differentiation prevails: RDSALES measures the importance of R&D expenditures in the different industries, whereas KHUM is focused on human capital intensity across sectors. The effect of the degree of concentration in the industries is included in the regression through the Herfindahl index. As it is commonly assumed in the literature, we expect a positive sign for the product differentiation variables and a negative sign for the degree of concentration indicator.

III.3 Econometric specification

The econometric specification most usually employed in empirical studies of intra-industry trade is the logistic function, as it ensures that the estimated values will be between the extreme values of

[14] Data for per capita income has been obtained from OECD *National Accounts*. Income distribution indicator comes from Deininger and Squire (1996).
[15] As our sample finishes in 1992, the countries considered belonging to the EU are those who where members at the time.

the Grubel-Lloyd index [0,1]. However, we will choose a different specification. As Figure IV shows, a high proportion of observations take the zero value of the index, what means that the distribution function of the sample has a cumulative point of probability for this value (in other words, there is a value with non-zero probability). Under these circumstances, the most suitable econometric specification is a *tobit* model. This type of model is usually employed for sets of data where the zero value is frequent and the rest of observations are positive. One obvious shortcoming of this approach is that it does not ensure fitted predictions; however, given that (a) our goal is not prediction and (b) we never get fitted values outside the limits of the closed interval [0,1], we will adopt a *tobit* specification.

[FIGURE IV]

IV. RESULTS FOR THE GRUBEL-LLOYD INDEX.

In Table I we report the outcome achieved by the previous set of explanatory variables. Three different dependent variables have been included in the regression: the adjusted Grubel-Lloyd index computed for total vertical trade (VIIT), and for both low- and high-quality vertical intra-industry trade ($VIIT^{LQ}$ and $VIIT^{HQ}$, respectively). As we have widely stated, one of the more important features of vertical differentiation models is that they allow us to explain which type of varieties will produce each country. Regarding the effect of relative factor endowments, two alternative approaches have been employed. First, we have used differences in per capita income as our sole indicator for differences in factor endowments (columns 1, 3 and 5). Secondly, the use of three different indicators allows us to distinguish differences in physical, human and technological capital endowments (columns 2, 4 and 6).

[TABLE I]

The results are quite similar for the three dependent variables. In the case of VIIT, we achieve a positive sign for the differences in per capita income (equation (1)). If we drop differences in per capita income and include differences in physical, technological and human capital indicators in

[16] Sectorial human capital intensity, defined as W_j-sL_j, where W_j are the total payments to labour force in sector j, L_j the number of employees and s the average wage for unqualified workers.

the regression (equation (2)), we also get a positive sign for all of them. According to these results, differences in endowments unambiguously enhance vertical intra-industry trade.[17]

This same positive outcome is achieved when Spain exports low-quality varieties (columns (3) and (4)), and when it exports high-quality varieties (columns (4) and (5)). At this point, our results make it difficult to postulate that differences in factor endowments play a different role depending on the type of vertical intra-industry. However, the patterns of trade that each type represents are quite different. We discuss this outcome later.

With regard to the other explanatory variables, the average income has a positive effect on all the indices of vertical intra-industry trade, except in the case of high-quality exports, where an unexpected negative sign is obtained. The negative relationship obtained in all cases for the Gini index confirms our initial expectations regarding the effect of income distribution. With regard to the industry variables, R&D expenditures, industrial intensity in human capital and the Herfindahl index are highly significant and present the expected signs.

The results displayed in Table I broadly confirm the evidence usually observed in empirical work: the higher the differences in endowments, the higher the value of the vertical Grubel-Lloyd index. At the same time, however, some difficulties arise when we interpret our evidence as a whole, because of two reasons: (a) each dependent variable measures quite different patterns of trade; (b) each indicator of differences in factor endowments implies quite different situations. Thus, VIIT computes the share of trade in a given industry where simultaneous exports and imports embody different levels of quality, but it does not report the relative position of trading partners. Therefore, our results for this variable imply that differences in relative factor endowments enhance the exchange of different varieties, whatever the type of vertical specialization of the abundant country on the one hand and the scarce country on the other. This same results hold when we distinguish vertical intra-industry trade in varieties for each sector where country A is the high-quality exporter of good *j* to country B ($VIIT^{HQ}$ if we consider Spain as A) and vertical intra-industry trade in varieties where country A is the low-quality exporter of the same good *j* to B ($VIIT^{LQ}$). The differences measured in factor endowments are the same in both cases, so that

[17] Our results confirm those of Greenaway, Milner and Elliot (1996) with respect to differences in physical capital per worker and those of Blanes and Martín (2000) with respect to differences in human and technological capital. However, these authors obtain a negative relationship between differences in per capita income and the Grubel-Lloyd index for vertical intra-industry trade. In this latter case, it is likely that our inclusion of the income distribution

they have the same effect on two types of trade that should respond to exactly the opposite forces. This happens despite the fact that, for instance, differences with countries which are more abundant than Spain in all three productive factors should improve their comparative advantage only in the high-quality set of varieties in each industry.

Up to this point, we have followed the most usual method in the study of intra-industry trade determinants, focusing on the Grubel-Lloyd index and (as recent tradition by Greenaway, Hine and Milner (1994,1995)) its vertical components. However, it is time we reconsidered whether analyzing the effect of factor endowments on vertical intra-industry specialization by employing the Grubel-Lloyd index is the proper approach. In the 2x2x2 framework developed in the model of Falvey and Kierzkowski, each country produces only one set of varieties (low or high-quality) in the differentiated product industry. However, when computing bilateral exchange of vertically differentiated products, we never find such a simple pattern of trade. Instead, it is easy to observe that in most industries the same country exports the high-quality varieties for certain products and the low-qualities in another set of products. The point that the model allows us to highlight is why some countries produce low or high-quality products *on average*. What we will do next, therefore, is to drop the Grubel-Lloyd index (and its different elements) as our dependent variable. Instead, we will measure the relative specialization of each country in the low or high-quality varieties for a given industry. We will do this by means of the percentage that each component of vertical intra-industry trade present regarding its total volume. Thus, despite in most industries we find both situations in which we export the high-quality varieties and those in which we are the low-qualities exporters, the ratio allows us to determine which pattern prevails in each sector and, therefore, which type of specialization characterizes it. Accordingly, in the following section we will focus on this relative specialization in the low or high-quality set of varieties in the different industries and with regard to the OECD countries in our sample.

indicator INCDIS frees differences in per capita income of measuring demand side effects, so that our positive sign is consistent with the results obtained in equation (2).

V. ANALYSIS OF VERTICAL INTRA-INDUSTRY TRADE SPECIALIZATION

Firstly, we show which share each type of intra-industry trade -HIIT, $VIIT^{LQ}$ and $VIIT^{HQ-}$, represent on the total intra-industry trade index (IIT). This information is reported in Table II.

[TABLE II]

It can be easily seen that the Spanish intra-industry trade with the OECD countries in the sample is mostly of a vertical type.[18] Besides, it is basically specialized in the lower set of qualities with regard to most of countries (representing in several cases more than 50% of intra-industry trade).[19] Only with regard to Portugal and New Zealand, vertical intra-industry trade is mostly characterized by Spanish high-quality exports. In general terms, this is consistent with the observed relative endowments, as shown in Figures I to III. Looking at the different industries in Table III just confirms this impression, as low-quality intra-industry trade represents more than 50% of intra-industry trade in about 50% of the industries.

[TABLE III]

Given the predominance of the low-quality varieties in the Spanish pattern of trade, the new dependent LQS_{jm} variable is built as the share that the *low-quality* vertical intra-industry trade represents on total vertical intra-industry trade:[20]

$$LQS_{jm} = \frac{VIIT_{jm}^{LQ}}{VIIT_{jm}}$$

This new indicator is, in fact, measuring the share that the *volume* of low-quality vertical intra-industry trade represents on the *volume* of total vertical intra-industry trade. Thus, the higher this share, the more specialized in low-qualities each industry will be. The new variable is only defined when vertical intra-industry trade with country *m* exists, and it ranges from zero (no low-quality exports to country *m*) to one (all vertical intra-industry trade with country *m* is characterized by Spanish exports beinglow-quality).

[18] Confirming therefore the evidence reported in Blanes and Martín (2000).

[19] In fact, it is only with regard to Portugal and New Zealand that Spain appears as the high-quality exporter, on average.

Some changes in the econometric approach are needed because LQS is defined only if the Grubel-Lloyd index for vertical trade VIIT is different from zero. Given that dropping those observations where VIIT=0 would introduce a selection bias in the estimations, we will adopt a two-stage estimation procedure developed by Heckman which will allow us to avoid the previous problem and achieve some interesting results.

Heckman s method[21] consists of estimating separately a probit equation and an ordinary least squares (OLS) equation. Thus, prior to the estimation to the equation above we must define the binary variable D_{jm} according to the following scheme:

$$D_{jm} = \begin{cases} 1 & \text{if } VIIT_{jm} \neq 0 \\ 0 & \text{if } VIIT_{jm} = 0 \end{cases}$$

This variable takes a value 1 if simultaneous exports and imports of vertically differentiated product exist, and 0 in the opposite case. Using D_{jm} as the dependent variable, we estimate the *probit* equation

$$Pr(D_{jm} = 1/z_{jm}) = F(\beta' z_{jm})$$

Those statistically significant variables will contribute to explaining exclusively the probability of appearance of vertical intra-industry trade flows. The next step consists of studying the determinants of LQS, provided that $VIIT_{jm}$ is different from zero. We should take into account the bias introduced because of the elimination of the zero observations from the sample when specifying the model, that is:

$$E\left(LQS_{jm} / VIIT \neq 0\right) = \delta' z_{jm} + E\left(u_{jm} / VIIT \neq 0\right)$$

where the vector z_{jm} represent the set of explanatory variables defined in section III.2 and the second term of the right side of the equality is proportional to the inverse of the Mills ratio. The estimation of the inverse of the Mills ratio can be obtained from the *probit* model estimated in the first stage of the analysis. Following this method, in Table IV we report the results of both the *probit* and the OLS estimations. As in Table I, both bilateral differences in income or all three indicators of factor endowments differences have been included alternatively in the estimation.

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[20] The results were quite similar if it was referred to total intra-industry trade.

[21] Heckman (1976).

[TABLE IV]

Let us get on to the results. First, all the variables measuring differences in factor endowments show a significant positive sign in the probit estimation. To interpret the signs displayed we must remember that it is a different specification from the preceding section: what we are actually obtaining is that some degree of differentiation in the factor endowments seem to be a condition for vertical intra-industry exchanges to appear. This outcome supports the idea that vertical intra-industry flows are driven by comparative advantage, but it does not mean that increasing differences should always enhance all vertical intra-industry trade, as the different patterns achieved for each variable in the second stage proves. When the proportion of *low-quality* vertical intra-industry trade is to be explained, the INCDIF indicator presents a highly significant negative parameter in the estimation (1). If we distinguish among factor endowments in estimation (2), mixed evidence appears. Differences in human capital also have a negative impact on the dependent variable, as well as differences in physical capital per worker, whereas differences in technology still display a positive sign. In these two latter cases, however, the parameters have not been found to be significant. Thus, increasing differences in human capital reduce relative specialization in the low-quality varieties; this result fits well with the fact that Spain is relatively abundant in this factor: so, increasing differences imply that its (relatively scarce) trade partner deepens its specialization in the low-quality set of varieties.

With regard to the other variables, the income indicator is always significant; the EU dummy is accepted in the *probit* estimation, whereas its significance in the OLS estimation varies: it is accepted in case (1) and rejected in case (2). The variable for income distribution is always significant in the *probit* equation, and always rejected in the OLS estimation. In the case of the industry variables, all of them are significant in the estimation of the *probit* model. In the OLS estimation, once again, some different results appear: HERF is rejected, whereas the other two indicators are still significant. A negative relationship is obtained for sectorial expenditure in R&D, whereas intensity in human capital has a positive effect. Thus, the negative relationship obtained for the Herfindahl index in the probit estimation could be interpreted in the sense that standarization discourages the appearance of vertical intra-industry trade, although it does not affect the type of specialization in each industry, as the non significance in the OLS estimation indicates. The results in this latter case show that specialization in the production of low quality varieties should be more prominent in industries with lower levels of research; however, the

production of differentiated production requires qualified employment whatever the quality we are producing.

Perhaps the most controversial among the indicators included in the set of expalantory variables is **HUMK**. In order to evaluate the sensiblity of the previous results to the indicators of differences in factor endowmemts that we have employed, we tried an alternative human capital indicator labelled **HUMKDIF (2)**.

HUMKDIF (2): Bilateral inequality in the share of population who is in age of taking advanced studies and who is currently studying them.

According to this new indicator, Spain is the eighth country in the ranking, below USA, Canada, Finland, New Zealand, Norway, France and Belgium. It is, therefore, relatively less abundant than when measured by the former indicator **HUMKDIF**. We replicate the estimations with the new indicator; the results are shown in Table V.

The change in the human capital indicator confirms the previous evidence, even though several differences appear in the significance of the factor endowment variables. Thus, although **HUMKDIF (2)** is not significant in the probit estimation, it is highly significant in the OLS estimation. Besides, the other indicators for differences in factor endowments, **KLDIF** and **RDDIF** are also statistically significant in the OLS estimation. The sign achieved in this latter estimation for **KLDIF** and **HUMKDIF (2)** is negative, whereas it is positive in the case of **RDDIF**. This means that bilateral differences in physical and human capital affect negatively the Spanish specialization in low-quality varieties, whereas differences in technology enhance it (let us remember that differences in technology mean, in our case, that Spain is in a position of disadvantage in relation to most of the countries in the sample). The results for the rest of variables are very similar to those displayed in Table IV.

VI. CONCLUDING REMARKS

In this paper we have dealt with the study of the determinants of vertical intra-industry specialization of Spanish trade with the OECD countries, paying special attention to the effect of differences in factor endowments as as source of comparative advantage. First, the data has shown that Spanish intra-industry trade with these countries is mostly characterized by the relative low quality of Spanish exports. In order to study the causes behind this pattern of trade, two approaches have been adopted. The first one implied the use of the traditional Grubel-Lloyd index for vertical trade as a dependent variable, considering different components of the index depending on the quality of the exported and imported varieties in each good. The second part of the analysis tried to establish the elements explaining the relative Spanish specialization in low-quality exports in the context of intra-industry exchanges. This second approach raised the most interesting results.

Our results suggest that certain degree of differentiation in factor endowments is required for vertical trade flows to appear; however, the effect of these differences on relative specialization depends on the relative endowments of each country. All considered, our evidence confirms that low-quality specialization predominates in countries where both human and physical capital are scarce and domestic investments in R&D are low. This explains the positive effect obtained in the present study for differences in technological capital, as Spanish investment in R&D is significantly lower than in most OECD countries, whereas it is relatively well-endowed of human capital, as the negative sign achieved for this indicator shows. The results for industry variables confirm this conclusion: we find that the more is spent in technology by firms, the less the share of low-quality varieties in sectorial intra-industry trade. Higher intensity in qualified labour intensifies it instead. In this case, however, it is likely that some degree of skilled labour is necessary to produce differentiated goods, whatever their level of quality. The previous scenery is quite coherent with the characteristics of the Spanish economy at the time of our sample. Spain has been a traditional importer of technology, although its labour supply is qualified enough to exploit the possibilities of the imported technology.

Other conclusions that stem from our results are the following ones: the existence of integration processes allows each country to deepen its commercial specialization according to its comparative advantages in front of those cases in which some trade barriers survive. The level of income of partner countries is significant and positive too, confirming the well-known result that higher levels of income enhance the demand for differentiated production. Finally, the more

evenly distributed the income, the more likely vertical intra-industry trade to appear, although this does not explain the level of quality in which countries specialize.

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FIGURE I: Human Capital (A)

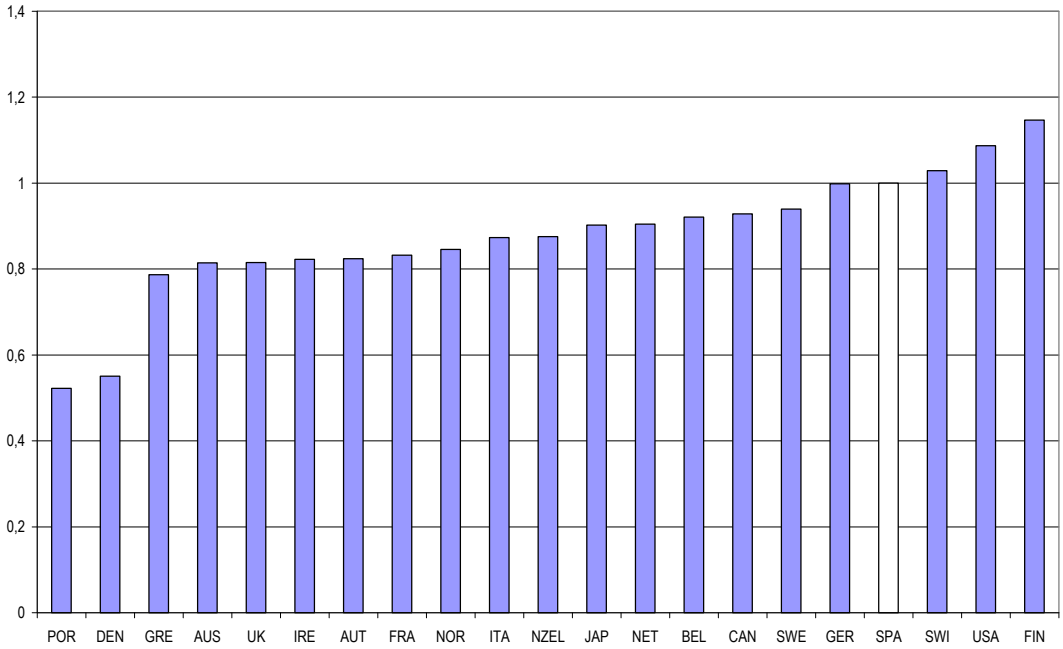

FIGURE II: R&D STOCK PER WORKER

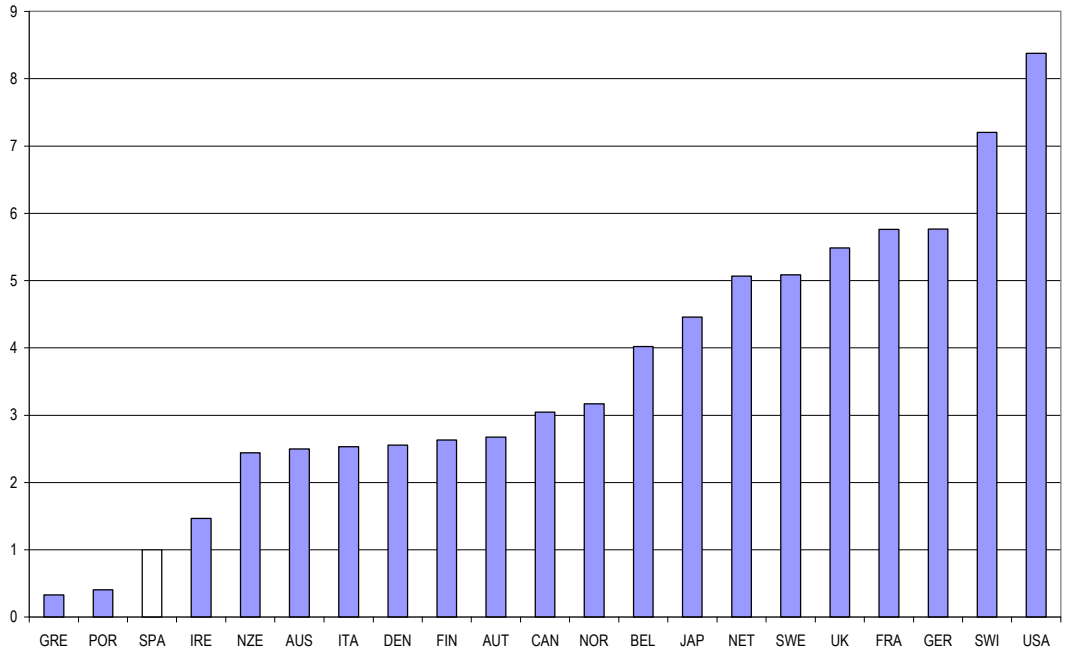

FIGURE III: PHYSICAL CAPITAL PER WORKER

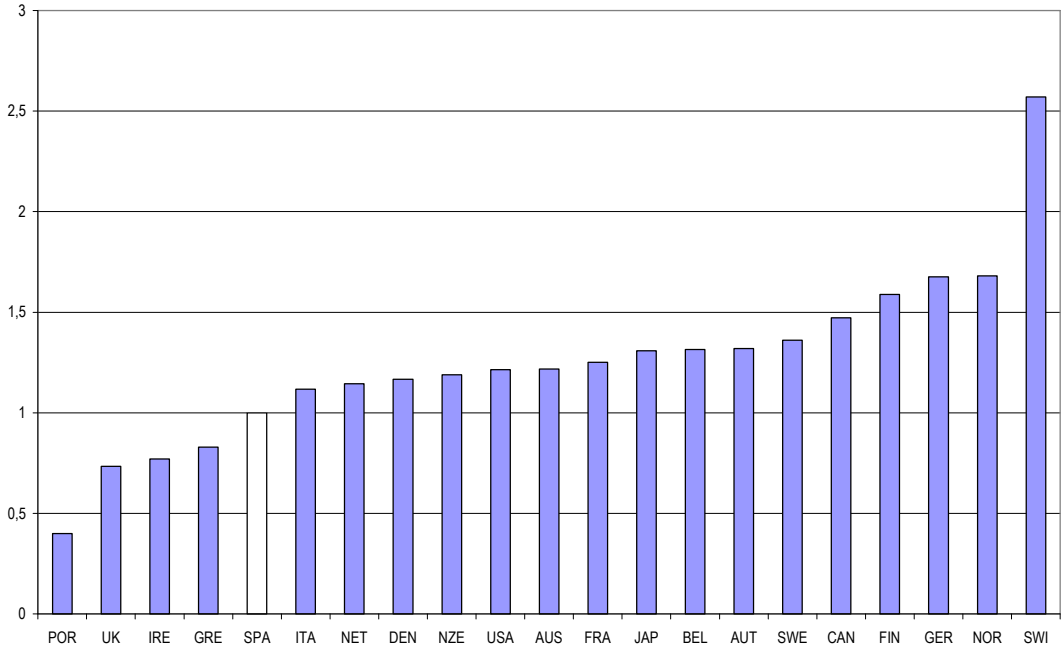

FIGURE IV: HISTOGRAM. Vertical Grubel-Lloyd index distribution

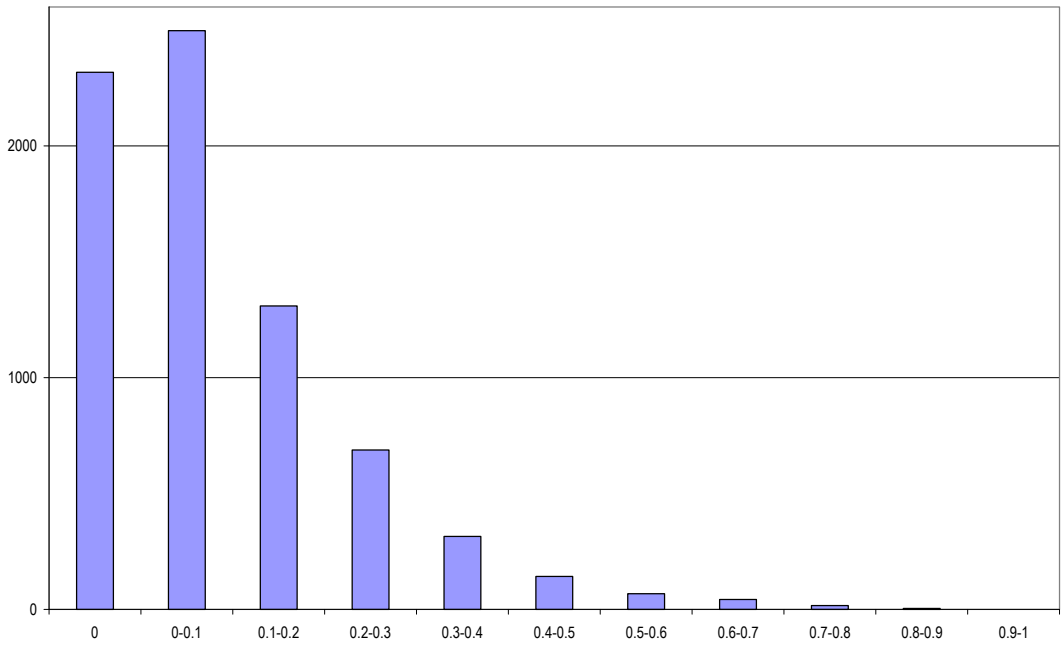

TABLE I: Determinants of vertical intra-industry trade (Grubel-Lloyd index)

	Total vertical IIT (VIIT)		*Low-quality exports ($VIIT^{LQ}$)*		*High-quality exports ($VIIT^{HQ}$)*	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.040 [0.129]	0.082 [0.001]	-0.072 [0.001]	-0.005 [0.798]	0.078 [0.000]	0.066 [0.000]
INCDIF	0.038 [0.000]	-	0.018 [0.000]	-	0.034 [0.000]	-
KLDIF	-	0.010 [0.000]	-	0.005 [0.005]	-	0.007 [0.000]
HKDIF	-	0.010 [0.000]	-	0.004 [0.061]	-	0.011 [0.000]
RDDIF	-	0.045 [0.000]	-	0.037 [0.000]	-	0.024 [0.000]
INCOM	0.014 [0.001]	0.013 [0.000]	0.029 [0.000]	0.018 [0.000]	-0.011 [0.000]	0.001 [0.465]
INCDIS	-0.016 [0.000]	-0.022 [0.000]	-0.011 [0.000]	-0.016 [0.000]	-0.010 [0.000]	-0.013 [0.000]
EU dummy	0.085 [0.000]	0.062 [0.000]	0.069 [0.000]	0.053 [0.000]	0.041 [0.000]	0.027 [0.000]
RDSAL	0.023 [0.000]	0.023 [0.000]	0.011 [0.000]	0.011 [0.000]	0.017 [0.000]	0.017 [0.000]
KHUM	0.026 [0.000]	0.027 [0.000]	0.029 [0.000]	0.302 [0.000]	0.006 [0.000]	0.006 [0.000]
HERF	-0.026 [0.000]	-0.027 [0.000]	-0.022 [0.000]	-0.023 [0.000]	-0.017 [0.000]	-0.017 [0.000]
Likelihood ratio	1518.38 [0.000]	1860.89 [0.000]	1434.94 [0.000]	1769.59 [0.000]	1107.58 [0.000]	1277.37 [0.000]
N. obs.	7321	7321	7321	7321	7321	7321
Positive obs.	5009	5009	4594	4594	4520	4520

TABLE II: SHARES OF VERTICAL AND HORIZONTAL FLOWS IN THE SPANISH INTRA-INDUSTRY TRADE
Average 1988-1992.

	Horizontal	Vertical			Horizontal	Vertical	
		High-q	Low-q			High-q	Low-q
France	0.26	0.20	0.54	*Norway*	0.10	0.42	0.48
Belgium-Lux.	0.22	0.30	0.48	*Sweden*	0.16	0.37	0.47
Netherlands	0.19	0.30	0.51	*Finland*	0.21	0.34	0.45
Germany	0.20	0.27	0.53	*Switzerland*	0.21	0.25	0.54
Italy	0.25	0.29	0.46	*Austria*	0.12	0.30	0.58
United K.	0.21	0.29	0.50	*U.S.A.*	0.11	0.30	0.57
Ireland	0.22	0.30	0.48	*Canada*	0.19	0.32	0.49
Denmark	0.14	0.32	0.54	*Japan*	0.15	0.31	0.54
Greece	0.16	0.42	0.42	*Australia*	0.28	0.26	0.46
Portugal	0.26	0.48	0.26	*N. Zealand*	0.23	0.45	0.32

TABLE III: SHARES OF VERTICAL AND HORIZONTAL FLOWS IN SPANISH INTRA-INDUSTRY TRADE
Industry Level. Average 1988-1992

	Horizontal	Vertical			Horizontal	Vertical	
		High-q	Low-q			High-q	Low-q
Iron and steel industry	0.45	0.13	0.42	Tinned fish	0.19	0.40	0.41
Non-ferrous metal industry	0.39	0.19	0.41	Milling	0.56	0.12	0.32
Non-metallic minerals and quarries	0.03	0.10	0.87	Bread and cakes	0.18	0.30	0.52
Cement, lime and plaster	0.04	0.30	0.66	Sugar	0.24	0.16	0.60
Concrete and cement by-products	0.14	0.45	0.41	Chocolates	0.27	0.24	0.49
Stones, abrasives and other non metallic mineral products	0.16	0.32	0.52	Animal food	0.12	0.38	0.50
Glasses and their manufactures	0.27	0.21	0.52	Other food stuffs	0.16	0.38	0.46
Ceramic products	0.14	0.33	0.53	Alcohols	0.16	0.44	0.41
Petrochemistry and organic chemistry	0.18	0.39	0.43	Liquors	0.07	0.41	0.52
Inorganic chemistry	0.21	0.19	0.60	Wine	0.19	0.32	0.49
Plaastic materials and rubber	0.43	0.13	0.44	Cider	0.26	0.33	0.41
Artificial and sinthetic fibres	0.37	0.36	0.26	Beer	0.56	0.20	0.24
Fertilizers and pesticides	0.29	0.20	0.51	Non-alcoholic drinks	0.30	0.34	0.36
Painting, varnish and ink	0.14	0.24	0.62	Tobacco	0.08	0.43	0.49
Perfume esences	0.10	0.31	0.59	Spinning and weaving industry	0.26	0.27	0.47
Other chemical products for industry	0.13	0.37	0.50	Knitwears	0.19	0.42	0.39
Pharmaceutical products	0.10	0.38	0.52	Apparels	0.21	0.38	0.41
Soaps, detergents and perfumery products	0.14	0.25	0.62	Carpets	0.16	0.33	0.50
Photographic products	0.25	0.37	0.38	Tanned products	0.24	0.43	0.33
Other chemical products for consumption	0.20	0.25	0.55	Leather	0.10	0.60	0.30

Metallic foundry products	0.15	0.24	0.61	Footwear	0.15	0.30	0.55
Metallic carpentry products	0.19	0.34	0.47	Dressmaking	0.14	0.44	0.42
Metallic goods	0.15	0.27	0.59	Furrier industry	0.11	0.26	0.63
Agricultural machines	0.17	0.31	0.52	Wood	0.13	0.28	0.59
Industrial machines	0.16	0.29	0.55	Wood industry	0.24	0.37	0.38
Office machines	0.15	0.53	0.32	Cork industry	0.13	0.22	0.65
Electric materials	0.20	0.29	0.51	Basketmaking and brush industry	0.21	0.35	0.44
Electronic materials	0.19	0.31	0.50	Wood furnitures	0.19	0.45	0.36
Automobiles and their components	0.35	0.07	0.58	Paper and cardboard	0.50	0.22	0.28
Ships and their components	0.25	0.45	0.30	Paper and carboard by-products	0.19	0.31	0.51
Railway products	0.07	0.17	0.76	Graphic arts and publishing	0.08	0.08	0.84
Airships	0.10	0.26	0.64	Transformation of cork	0.33	0.19	0.48
Other means of transport	0.26	0.35	0.39	Transformation of plastic materials	0.17	0.22	0.61
Precision and optic instruments	0.12	0.39	0.49	Jewelry	0.15	0.49	0.36
Oils and greases	0.72	0.05	0.23	Musical instruments	0.17	0.32	0.51
Meat industry	0.20	0.44	0.36	Photographic and film laboratories	0.14	0.49	0.37
Muilk and dairy products	0.38	0.37	0.25	Toys	0.26	0.29	0.45
Tinned vegetables	0.25	0.50	0.25	Other manufactures	0.15	0.33	0.52

TABLE IV: Determinants of vertical intra-industry trade specialization (LQS)

	(1)		(2)	
	Probit	*OLS*	*Probit*	*OLS*
Constant	0.622 [0.004]	0.163 [0.048]	1.001 [0.000]	0.332 [0.000]
INCDIF	0.315 [0.000]	-0.062 [0.001]	-	-
KLDIF	-	-	0.095 [0.000]	-0.003 [0.698]
HUMKDIF	-	-	0.088 [0.000]	-0.023 [0.001]
RDDIF	-	-	0.401 [0.000]	0.016 [0.244]
INCOM	0.140 [0.000]	0.101 [0.000]	0.144 [0.000]	0.049 [0.000]
INCDIS	-0.146 [0.000]	0.003 [0.763]	-0.203 [0.000]	-0.008 [0.358]
EU dummy	0.665 [0.000]	0.026 [0.317]	0.507 [0.000]	0.050 [0.002]
RDSALES	0.271 [0.000]	-0.020 [0.005]	0.276 [0.000]	-0.016 [0.012]
KHUM	0.268 [0.000]	0.044 [0.000]	0.288 [0.000]	0.053 [0.000]
HERF	-0.299 [0.000]	0.015 [0.242]	-0.315 [0.000]	0.005 [0.669]
Mills ratio	-	-0.034 [0.671]	-	0.017 [0.787]
Likelihood ratio	1581.6 [0.000]	225.2 [0.000]	1939.2 [0.000]	232.4 [0.000]
Numb. obs.	7320	5009	7320	5009
Positive obs.	5009		5009	

NOTE: Figures in brackets are p-values.

TABLE V: Determinants of vertical intra-industry trade specialization (LQS)		
	Probit	*OLS*
Constant	0.851 [0.000]	0.374 [0.000]
KLDIF	0.123 [0.000]	-0.013 [0.058]
HUMKDIF (2)	-0.013 [0.443]	-0.030 [0.000]
RDDIF	0.369 [0.000]	0.027 [0.020]
INCOM	0.157 [0.000]	0.038 [0.000]
INCDIS	-0.186 [0.000]	-0.005 [0.527]
EU dummy	0.548 [0.000]	0.024 [0.168]
RDSALES	0.275 [0.000]	-0.018 [0.004]
KHUM	0.286 [0.000]	0.048 [0.000]
HERF	-0.321 [0.000]	0.010 [0.348]
Mills ratio	-	-0.017 [0.787]
Likelihood ratio	1922.38 [0.000]	245.45 [0.000]
Numb. obs.	7320	5009
Positive obs.	5009	