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A TWO-STAGE ANALYSIS OF MONOPOLISTIC COMPETITION MODELS OF INTRA-INDUSTRY TRADE

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In this paper we propose a new approach to testing the main implications of monopolistic competition models with regard to intra-industry trade (IIT). We pay particular attention to two questions: the econometric specification that best fits the theory and the role played by country and industry variables. The analysis focuses on Spanish horizontal IIT with the OECD during the 1988-1992 period. The methodology we adopt allows us to distinguish between the effect that the traditional determinants of IIT have on the existence of these types of flows, and the effect on their intensity. Some of the ambiguities that can be observed in the literature in relation to industry characteristics do not appear in our results. Thus, one of the more interesting findings is the relevance of the indicators of sectoral characteristics to the existence of (horizontal) IIT, but not to its intensity.

Keywords: Intra-industry trade, economies of scale, factor endowments.

(*JEL* F12, F14)

1. Introduction

The study of the determinants of intra-industry trade is one of the fields of international economics that has generated most of the empirical investigation in the last twenty years. In most cases, the theoretical foundations for the research were provided by the monopolistic competition models developed in the early eighties.[1] However, the existence of a definite link between the main implications of these models and empirical studies has been questioned recently. Leamer (1994) and

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[1]Krugman (1979, 1980, 1981), Lancaster (1980), Helpman (1981) and Ethier (1982).

Leamer and Levinsohn (1995) have described this relationship as pure chance, and criticized the simultaneous employment of variables which are intended to represent features derived from different theories, resulting in what they call a *grab-bag approach.* Two sorts of explanatory variables are usually involved in this type of analysis: on the one hand, country determinants reflecting bilateral differences in per capita income and/or factor endowments; and on the other hand, industry determinants such as measurements of the degree of scale economies and product differentiation. Considered overall, this literature has produced mixed results: as Greenaway and Torstensson (1997) pointed out recently, country characteristics perform much better than industry characteristics, in the sense that the results with the former are closer to initial expectations than in the case of the latter. Certainly, one of the reasons for this outcome may be the low quality of most of the indicators usually employed[2]. However, this cannot be the only reason, and other factors should be taken into account.

First, the framework established by monopolistic competition models was intended to explain trade in products which are quite similar in terms of cost structures and patterns of demand[3], that is, horizontal intra-industry trade. Consequently, it should not be surprising that the implications of these models do not fit well, in general terms, with the empirical evidence for total intra-industry trade: as recent empirical research has showed, most of the observed intra-industry trade is vertical type (with supply conditions differing between partner countries). Thus, it is likely that such a specific theoretical structure is too narrow to encompass all the feasible cases; indeed, these models should perform better if we restricted our study to trade between horizontally differentiated goods than for total intra-industry trade. Second, it is worthwhile to think out again the theoretical relationship that can effectively be established (and, therefore, tested) between horizontal intra-industry trade on the one hand and both country and industry indicators on the other. Thus, it could be inferred from a careful reading of monopolistic competition models that some factors are more relevant to the explanation of the presence of intra-industry

[2]Torstensson (1996) observes a high degree of instability in the results obtained with industry determinants, depending on the type of indicator employed. His results are in accordance with Krugman's (1989) criticisms: "What is clear is that the data do not provide a very good correspondence to the theoretical concept".

[3]Davis (1995) called perfectly-intraindustry goods those products embodying identical factor proportions.

flows, while others can have greater influence on determining their intensity. If this is correct, it implies the existence of two levels in the empirical analysis of intra-industry trade.

The scope of the paper is therefore defined as providing a reasonable answer to these basic questions. First, in considering the existence and the level of intra-industry trade as separate subjects, we are in fact suggesting a different methodological approach to the study of intra-industry trade which is based on both the distribution of the data and the theoretical framework; thus, a two-stage econometric specification will be proposed as an alternative to the usual logistic function. The second change comes from concentrating on horizontal intra-industry trade, following in this case the same trend as most empirical research in recent years. Our data set encompasses trade flows between Spanish industry and the main countries in the OECD, during the period 1988-1992. The rest of the work is organized as follows: firstly, we discuss the role played by the different determinants included in the regression analysis. Once the relationship we expect to find between those determinants and the intra-industry trade indicator is established, we define the indicators employed to measure the theoretical concepts. Finally, we comment on the results obtained for horizontal intra-industry trade.

2. Re-reading the theoretical framework

Since the very beginning, the preference for variety on the demand side combined with the presence of economies of scale on the production side was considered a major force behind the appearance of intra-industry trade. Thus, the theoretical developments appearing in the late 70's and the early 80's modelled intra-industry flows according to a monopolistic competition framework where product differentiation exists[4]. Although they are widely known, it will be useful to summarize the basic elements of these models first. All countries demand every variety available; however, only a small number of them is domestically produced. This happens because of the presence of increasing returns to scale, which favours the concentration of production by limiting the optimal number of varieties which may be produced in each country. Therefore, both product differentiation and the presence of economies of scale play a crucial role in the *appearance* of intra-industry trade.

[4]The main conclusions from this theoretical framework were synthesized in Helpman and Krugman (1985).

However, it is not obvious how an increase in the degree of product differentiation or in the level of economies of scale would affect the share of intra-industry trade (as usually measured by the Grubel-Lloyd index). In fact, it looks as if the role played by country features is the basic point of interest of these models, whereas industry characteristics just serve to define the framework in which intra-industry trade appears. In this regard, the only clear implication is that the proportion of intra-industry trade is related to those country features that could become a source of comparative advantage (mainly differences in factor endowments)[5]. Thus, Helpman (1981) and Krugman (1981) pay special attention to the relationship between the share of intra-industry trade and the country's relative factor endowments, whereas Krugman (1980) refers mainly to the effect of scale economies on the volume of trade. None of them expressly analyses whether the degree of scale economies and/or product differentiation[6] have any effect on the percentage of trade that can be considered intra-industry type. It is Ethier (1982) who explicitly tackles this question; he concludes that the intra-industry trade index should not vary with changes in the parameters which characterize the degree of scale economies and product differentiation.[7]

Let us briefly explain the way Ethier reaches this result.[8] His model considers two productive factors (capital and labour) and two sectors. The first one produces horizontally differentiated intermediate products (c) which "contribute in totally symmetric fashion to the finished manufactures"; the second sector produces an homogeneous good. The latter one is produced under constant returns to scale, whereas the CES production function for the final manufactured good

[5]In fact, these are the only ones tested in Helpman (1987).

[6]In most of this literature, the parameters defining the degree of scale economies and product differentiation are directly related by the equilibrium conditions.

[7]Similarly, Harrigan (1994) pointed out recently that, provided there are no cross-country differences in the effect of scale economies, any change in the technological parameters which affects proportionally the import and export flows in a given sector will leave the Grubel-Lloyd index unchanged. This argument leads Harrigan to concentrate on the "volume of trade rather than to look at the proportion of intra-industry trade" to check the effect of scale economies.

[8]In fact, the framework of Ethier's model is quite similar to Krugman's (1980). The main difference is that in Ethier's, intra-industry trade consists of intermediate goods that are assembled at the location of consumers and in Krugman's final goods are traded (having been assembled at the location of producers).

y is

$$Y = n^{\rho}\left[\sum_{i=1}^{n}\left(\frac{c_i^{\theta}}{n}\right)\right]^{\frac{1}{\theta}} \qquad [1]$$

where c_i indicates the volume of production of variety i and n is the number of varieties of the differentiated (intermediate) good, $\rho > 1$ and $\theta \in (0,1)$. In equilibrium, the production of an amount c_i of variety i requires a bundle of productive factors (capital and labour) given by the expression $ac_i + b$ (where $a, b > 0$). Because of the fixed costs introduced by the presence of b, scale economies exist. Further, we can define $m = n(ac_i + b)$ and $m^* = n^*(ac_i + b)$, which stand for the bundles of productive factors employed in the differentiated good industry home and abroad, respectively. We could also regard them as indicators of the scale of operations of the industry in both countries.

Under the assumption of identical technologies in all countries (implicit in the definitions given for m and m^*), it is possible to express the output of each variety and the number of varieties produced home and abroad, in terms of the structural parameters previously defined:

$$c = \frac{b\theta}{a(1-\theta)} \qquad [2]$$

$$n = \frac{(1-\theta)m}{b}; n^* = \frac{(1-\theta)m^*}{b} \qquad [3]$$

As an implication of the above structure, the volumes of exports (X) and imports (M) in the differentiated product industry between the two countries are $X = g^*cn$ and $M = gcn^*$, respectively; g and g^* represent the relative size of the two countries. Consequently, the usual Grubel-Lloyd index can be written as:

$$IIT = 1 - \frac{|X - M|}{X + M} = 1 - \frac{|g^*cn - gcn^*|}{g^*cn + gcn^*} \qquad [4]$$

Thus, both country and industry characteristics appear in the intra-industry trade index and determine its value. However, if we substitute the equilibrium conditions [2] and [3] in [4] and simplify, we get

$$IIT = 1 - \frac{\left|g^*\left(\frac{1-\theta}{b}\right)m - g\left(\frac{1-\theta}{b}\right)m^*\right|}{g^*\left(\frac{1-\theta}{b}\right)m + g\left(\frac{1-\theta}{b}\right)m^*} = 1 - \frac{|g^*m - gm^*|}{g^*m + gm^*} \qquad [5]$$

Consequently, the variability of the intra-industry trade index depends only on the relative size of the countries and the quantity of resources

devoted to the production of the differentiated products, represented by the pairs (g, g^*) and (m, m^*), respectively:[9] in other words, the amount and the allocation of the resources. But no parameter related to the degree of product differentiation or economies of scale appears in the index, either directly or indirectly.[10] This happens because we are dealing with equilibriums where the same price is set for each variety of the differentiated product, given identical technology. Thus, the horizontal nature of the product differentiation that is being considered in the monopolistic competition framework is emphasized. This result allows Ethier (1982) to conclude that both scale economies and product differentiation play a knife-edge role in the theory of intra-industry trade: they are necessary for it to appear, but they do not affect its relative level.

In spite of the above, no empirical attempt has been made to check whether two separate roles for explanatory variables can be established. Instead, it has been common practice since the studies by Pagoulatos and Sorensen (1975) and Loertscher and Wolter (1980) to include indicators which reflect inter-sectoral differences in the industry characteristics,[11] which amounts to testing the existence of a direct relationship between these characteristics and the share of intra-industry

[9] Those countries abundant in the factors intensively employed in the production of varieties will devote more resources to this and, consequently, produce a greater number of them. Thus, if the differentiated product is capital-intensive (and that is the current hypothesis) the share of varieties produced in the capital abundant country will be greater than the proportion of world production in that country (in other terms, $n/n^* > g/g^*$ when $m/m^* > g/g^*$). In other words, a rise in the endowment of capital per worker in the home country (or, equivalently, a fall in the foreign country) will increase the ratio n/n^*. According to these results and taking into account that

$$\frac{\partial CII}{\partial(m/m^*)} = \begin{cases} < 0 \text{ if } \frac{m}{m^*} > \frac{g}{g^*} \\ > 0 \text{ if } \frac{m}{m^*} < \frac{g}{g^*} \end{cases}$$

we can easily see that an increase in the home endowments will decrease the proportion of intra-industry flows if home is relatively abundant in capital, and it will increase it otherwise.

[10] Changes in these parameters do not affect the pairs (g, g^*) and (m, m^*). The allocation of resources (that is, m and m^*) is determined according to Heckscher-Ohlin patterns. On the other hand, the total output of the differentiated products is invariable, as changes in the parameters have offsetting effects on the output of each variety and the number of varieties.

[11] This must probably be due to the fact that "empirical work came first" (Leamer and Levinsohn, 1995), as when these initial efforts appeared (establishing the pattern for the subsequent research) the body of theory had not developed enough to provide testable implications beyond simple correlations.

trade. Although this approach is justified if asymmetrical conditions in production and demand prevail in the partner countries (see [4]), it is questionable if we focus on horizontal intra-industry trade, as we will try to prove in the econometric study. Prior to this, the set of indicators for the explanatory variables is defined in the following section.

3. Determinants of intra-industry trade

One of the problems that have been previously mentioned with regard to empirical analysis of intra-industry trade refers to the poor quality of available measurements of the theoretical concepts. The search for some improvements in this area, however, lies outside the aims of this paper, so that the best solution we can provide to this problem is to choose the most suitable indicators among those available. Hence, we will be quite conservative in the set of exogenous variables, although we will try to link clearly all the variables considered with the theoretical framework.

The testable conclusions stemming from the monopolistic competition models we are interested in are the following ones:

a) Intra-industry trade appears as some countries exchange different varieties of the same good, because the presence of economies of scale favours each country specializing exclusively in a few varieties. Similarity in consumer preferences, independently of their location, means that in every country there is demand for every variety.[12] Consequently, we include some economies of scale and product differentiation indicators that have been widely employed in the literature.[13]

[12] Note, however, that in this point we are only considering conditions which permit the appearance of intra-industry flows.

[13] Although we shall include several product differentiation indicators simultaneously, we rule out the existence of some degree of co-linearity between industry indicators, as the correlation matrix shows:

Correlation matrix

	*SE*1	*SE*2	*RD*	*HUMK*	*HERF*
*SE*1	1.00				
*SE*2	0.19	1.00			
RD	0.08	0.12	1.00		
HUMK	−0.21	0.12	0.06	1.00	
HERF	0.18	0.14	0.10	0.21	1.00

SE1: Economies of scale indicator by Caves, Khalilzadeh-Shirazi and Porter (1975).[14]

SE2: Economies of scale indicator by Greenaway y Milner (1984).[15]

RD: R&D expenditure as a percentage of sales.

HUMK: Human capital intensity in the industry.[16]

HERF: Herfindahl index of industry concentration.

There are no clear expectations regarding this latter variable. It seems that the number of firms in the industry (hence, the degree of concentration) must play a similar role to industry characteristics such as scale economies and product differentiation, as long as both of them contribute to explain the number of firms producing in the industry. However, the relationship between product differentation and number of firms in the industry is not determined in a straightforward manner. Thus, Lancaster (1980) concludes that the number of varieties produced is maximized when a market structure entailing a high number of firms exists; hence, a low degree of concentration would encourage intra-industry trade. Despite this, Shaked and Sutton (1987) show that, in a horizontal differentiation framework, both a highly concentrated and a highly fragmented market structure are possible.

b) The share of intra-industry trade will be inversely related to the existence of sources of comparative advantage, fundamentally differences in relative factor endowments. So, greater similarity in endowments allows us to expect a higher proportion of this type of flows. At this

[14] This is based on the concept of minimum efficient size (*MES*). The authors define the minimum plant size in a sector starting from the total gross production of the firms corresponding to that size of plant i which contains the mean point of the accumulative distribution of production in the sector, divided by the number of plants included in that category. This minimum efficient size is expressed as a percentage of the sector production, so the variable *MES* can be defined as $(PB_i/n_i)/PB$. This measure is weighted by the quotient of the average added value per worker in the smaller firms which constitute 50% of the total added value of the sector and the average added value per worker in the larger firms which represent 50% of the total added value of the sector (*CDR*). Consequently, the first indicator of economies of scale is defined as $SE1 = MES/CDR$

[15] In this case, the variable is defined as the quotient of the added value per worker in the plants included in the segment of firms of greatest size in the industry and the added value per worker in the others.

[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.

point, however, some comments are needed. If factor payments are the only source of income and preferences are homothetic, a direct link can be established between similarity in factor endowments and similarity in per capita income of two countries.[17] This relationship has been reflected in the empirical analysis: Loertscher and Wolter (1980), Balassa (1986) and Balassa and Bauwens (1987) use differences in per capita income in order to measure the effect of the differences in endowments on intra-industry trade. On the other hand, Markusen (1986) returns to Linder's (1961) theses about the role of per capita income as an indicator of similarity in preferences. Following the same line, Bergstrand (1990) highlights the importance of considering separately supply factors (differences in factor endowments) and demand factors (differences in preferences). According to this view, a greater differential in per capita incomes would imply a greater disparity in the preferences of the countries, which would be reflected in lower relative levels of intra-industry trade. As a mechanism which could help in separating supply and demand considerations, we chose to include both indicators. We have built up the well-known Balassa indicator of relative inequality[18] between Spain and each OECD country for them both. Additionally, the presence of economies of scale in production gives the countries' market sizes a relevant role (intra-industry flows will be more important, in relative terms, in countries with a similar market size). Therefore, a Balassa indicator for market size differentials is also included.[19]

DKW: Inequality in capital per worker endowments.

DPC: Inequality in per capita GDP.

DGDP: Inequality in GDP.

c) Bergstrand (1990) pointed out some additional country variables to be considered in relation to variations in the share of intra-industry trade. Starting from the role played by countries' incomes, the central hypothesis of the Markusen-Bergstrand approach is that the differentiated goods that constitute the nucleus of intra-industry trade have an

[17] Clifton and Marxsen (1984).

[18] Defined by the expression

DY Rel.$= 1 + \left[\frac{Y_i}{Y_i+Y_j} \ln\left(\frac{Y_i}{Y_i+Y_j}\right) + \frac{Y_j}{Y_i+Y_j} \ln\left(\frac{Y_j}{Y_i+Y_j}\right)\right]$ where Y is the variable for which we are calculating the differences between countries i and j.

[19] Data for GDP and per capita GDP come from the *National Accounts* of the OCDE, and capital per worker estimates are taken form the Penn World Tables. Industry variables come from the Spanish *Encuesta Industrial*.

income elasticity superior to one (dropping, therefore, the Helpman-Krugman assumption of homothetic preferences). Consequently, we should expect a greater intensity of exchange of differentiated products between those countries that have a higher income level.

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

Besides we should expect that a greater joint market size affects positively the intensity of intra-industry trade, as long as it permits a greater development of varieties (Bergstrand, 1990). In the same way, it is widely accepted that intra-industry flows are stimulated if the countries are involved in economic integration processes. In our case, incorporating this effect implies a special treatment of trade with the countries belonging to the European Union. Thus, the following variables were included in the regression analysis:

GDP: Arithmetic mean of the GDPs of Spain and each OECD country.

EU: Dummy variable for the countries belonging to the European Union.

BORDER: Dummy variable for France and Portugal.

4. Econometric specification and results

In order to measure intra-industry trade, we have used an adjusted Grubel-Lloyd index, defined by the following expression:

$$IIT_{js} = 1 - \frac{\sum_{i=1}^{I} |X_{ijs} - M_{ijs}|}{X_{js} + M_{js}}; j = 1...J,\ s = 1...S \qquad [6]$$

where we compute the import and export flows with country s in sector j, weighted in accordance with the relative share of the trade flows in the I subsectors included in j.[20] The index ranges from 0 (absence of intra-industry trade) to 1 (all trade is intra-industry).

[20] The index has been calculated for 76 industries ($J = 76$) in the Spanish *Encuesta Industrial* with respect to 20 countries of the OECD ($S = 20$): France, Belgium-Luxembourg, Netherlands, Germany, Italy, United Kingdom, Ireland, Denmark, Greece, Portugal, Norway, Sweden, Finland, Switzerland, Austria, United States, Canada, Japan, Australia and New Zealand. The trade data has been obtained from the EUROSTAT database, with information about exports and imports up to an eight-digit level in product categories in the Brussels Tariff Classification, regrouping those entries in order to adapt them to the taxonomy used by the Spanish *Encuesta Industrial*, based on the National Classification of Economic Activities.

However, we are not going to consider the whole trade flows existing in each industry: the implications of the monopolistic competition models (especially those summarized in Section 2) refer basically to the case of horizontal differentiation. Thus, we will distinguish between horizontal and vertical trade flows and restrict our analysis to those trade flows which can be considered as horizontal ones. In order to classify trade in accordance with the type of product differentiation, we have relied upon the method proposed by Abd-al-Rahman (1991). This procedure considers trade in each product as horizontally or vertically differentiated, depending on the degree of divergence between export and import unit values of each variety i with respect to a country s, UVX_{is} and UVM_{is}, respectively.[21] Thus, we consider that intra-industry trade is horizontal if

$$1-\alpha < \frac{UVM_{is}}{UVX_{is}} < 1+\alpha \qquad [7]$$

The inequality [7] must reflect properly the price differentials that can be attributed to differences in quality between the imported and the exported varieties. In this sense, the value we choose for the parameter α will not be neutral, as it affects the accuracy of our definition of horizontal differentiation (in the extreme case shown in the theoretical model, with no transportation cost, $\alpha = 0$).[22] In our case, we choose

The number of eight-digit categories (I) in each industry j changes from one case to another.

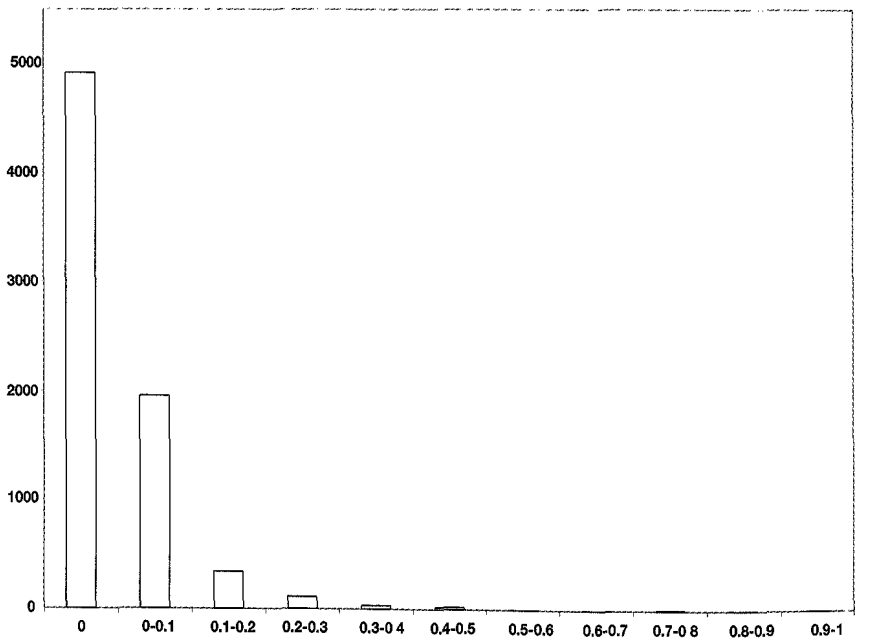
[21] In order to make these unit values respond to the concept of price of the different varieties with the greatest degree of reliability attainable, the available information was employed with the maximum detail possible in each sector. Thus, we used the information from the database EUROSTAT up to an eight-digit level again.

[22] Most papers dealing with this topic try different values for α, usually 15% and 25% –see Abd-al-Rahman (1991), Greenaway, Hine and Milner (1994, 1995) and Aturupane, Djankov and Hoekman (1999)–. Obviously, there is a trade-off between defining horizontal intra-industry trade too narrowly (labelling, therefore, differences in prices caused by, e.g., transportation costs, as quality-induced differentials) and too broadly (which could mean labelling vertical trade as horizontal trade). A set of papers by Boskin *et al.* (1998) and Nordhaus (1998), among others, recently considered this same topic from a different point of view. These authors tried to establish to what extent increases in prices respond to inflationary processes or whether they just reveal significant differences in the quality of the products. Their analyses, which imply a higher level of aggregation than ours, show that less than 1% of the variation of the CPI is related to variations in the quality of the goods. This means that differences of ±15% between the export and import prices seem to be enough to drop the vertically differentiated products, despite the spatial differentiation of the products considered.

the value $\alpha = 15\%$, as our main goal is to get a strict definition of horizontal intra-industry trade.

Let us turn to the econometric specification now. It has always been open to debate in the literature about intra-industry trade, due fundamentally to concern about obtaining fitted values inside the closed interval [0,1]. From this perspective, the most appropriate solution probably consists of estimating a logistic specification (Balassa, 1986). However, the statements presented in Section 2 suggest that the information provided by the zero and non-zero values of the index is qualitatively different. Thus, the former means that there is no intra-industry trade, whereas the latter indicates both the existence of intra-industry trade and the share that it represents. From a strictly econometric perspective, this qualitative difference between zero and non-zero values of the index implies the existence of an accumulation point in the probability distribution function around zero (see Figure 1).

FIGURE 1
Histogram. Distribution of the Grubel-Lloyd index



As the logistic specification considers all the observations in the same way, a tobit model seems to be the most suitable econometric specification.[23] However, a standard tobit model, although it is appropriate

[23] Besides, achieving fitted values inside the [0,1] interval becomes relatively less

to the structure of the data, does not allow us to investigate the existence of two levels to characterize the determinants of intra-industry trade. Let us argue as if there were two decisions to be made: the first one about engaging in intra-industry trade with another economy or not, and the second one about the relative level which those exchanges should reach. This distinction is clear if we express the expected value of the intra-industry trade index, conditioned by our set of explanatory variables, in the following way:

$$E(IIT/z_{jm}) = P(IIT > 0/z_{jm})E(IIT/z_{jm}, IIT > 0) \qquad [8]$$

where z_{jm} is the set of explanatory variables. The term $P(IIT/z_{jm})$ indicates the probability of the existence of intra-industry trade; and $E(IIT/z_{jm}, IIT > 0)$ shows us the expected value of the intra-industry trade index in those cases in which it is different from zero. It seems more suitable to estimate an econometric specification which allows us to distinguish these two levels. As the standard tobit model involves a single estimation for both decisions, an alternative specification is required.

A computationally simple method to estimate the parameters associated with the z_{jm} variables was proposed by Heckman (1976). His method consists of estimating separately a probit equation and an ordinary least squares (OLS) equation. Thus, we first define the binary variable D_{jm}, which takes a value 1 if simultaneous exports and imports exist, and 0 in the opposite case.

$$D_{jm} = \begin{cases} 1 \text{ if } IIT_{jm} \neq 0 \\ 0 \text{ if } IIT_{jm} = 0 \end{cases} \qquad [9]$$

Using D_{jm} as the dependent variable, we estimate the econometric model

$$D_{jm} = \beta' z_{jm} + \varepsilon_{jm} \qquad [10]$$

The variables which turn out to be significant will contribute to explaining exclusively the probability of appearance of intra-industry trade flows, without taking into consideration their volume and/or intensity. Once we have analysed the causes of the appearance of the phenomenon, the next step consists of studying the determinants of its intensity. The econometric model in this case would follow the expression

$$IIT_{jm} = \delta' z_{jm} + u_{jm} \text{ if } D_{jm} = 1 \qquad [11]$$

important if the object of the study is not prediction, as in our case. Anyway, we never get fitted values outside the interval.

At this stage, we only take into account those observations where there is intra-industry trade ($IIT_{jm} > 0$), so we only want to analyse its intensity. When specifying the model, however, we should take into account the bias introduced because of the elimination of the zero observations from the sample; that is:

$$\begin{aligned} E(IIT_{jm}) &= \delta' z_{jm} + E(u_{jm} \mid IIT_{jm} \neq 0) \\ &= \delta' z_{jm} + E(u_{jm} \mid D_i = 1) \end{aligned} \quad [12]$$

$$E(IIT_{jm}) = \delta' z_{jm} + \sigma \frac{\phi(\gamma' z_{jm})}{\Phi(\gamma' z_{jm})} \quad [13]$$

where $\gamma = \beta/\sigma_1$ (σ_1 being the standard deviation of the disturbance term ε_{jm}), while $\sigma = \sigma_{12}/\sigma_1$ (σ_{12} being the covariance between the disturbance terms in both equations) and the quotient $\phi(\cdot)/\Phi(\cdot)$ is the inverse of the Mills ratio. The estimate of the inverse of the Mills ratio can be obtained from the probit model estimated in the first stage of the analysis.

TABLE 1
Horizontal intra-industry trade (α=15%). Two-stage model.

	STAGE I (Probit)				STAGE II (OLS)			
	(1)	P-value	(2)	P-value	(3)	P-value	(4)	P-value
C	-1.101	[0.000]	-1.100	[0.000]	-0.178	[0.086]	-0.182	[0.078]
PC	0.229	[0.000]	0.222	[0.000]	0.022	[0.045]	0.022	[0.041]
GDP	0.554	[0.000]	0.550	[0.000]	0.047	[0.040]	0.049	[0.038]
DKW	0.276	[0.000]	0.274	[0.000]	0.029	[0.026]	0.030	[0.024]
DPC	-0.366	[0.000]	-0.360	[0.000]	-0.047	[0.009]	-0.047	[0.008]
DGDP	-0.421	[0.000]	-0.420	[0.000]	-0.037	[0.025]	-0.038	[0.023]
BORDER	0.270	[0.000]	0.268	[0.000]	0.026	[0.006]	0.026	[0.005]
EU	0.467	[0.000]	0.465	[0.000]	0.035	[0.078]	0.036	[0.067]
SE1	-0.096	[0.000]	-		-0.006	[0.211]	-	
SE2	-		0.004	[0.833]	-		-0.001	[0.626]
RD	0.101	[0.000]	0.092	[0.000]	0.004	[0.299]	0.004	[0.289]
HUMK	0.206	[0.000]	0.230	[0.000]	0.012	[0.123]	0.014	[0.102]
HERF	-0.197	[0.000]	-0.221	[0.000]	0.013	[0.094]	0.011	[0.190]
Inv. Mills	-		-		0.126	[0.048]	0.131	[0.043]
R^2	-		-		0.15		0.15	
pseudo-R^2	0.19		0.19		-		-	
$-2(L_0-L_1)$	1789.34	[0.000]	1763.29	[0.000]	222.38	[0.000]	222.47	[0.000]
Fraction of correct predictions	75%		75%		-		-	
N. Obs.	7321		7321		2429		2429	

Note: The values in brackets represent the marginal significance level of the tests.

The results stemming from the estimation of Heckman's model are presented in Table 1. The probit equations are reported in regressions [1] and [2], and the OLS estimations in regressions [3] and [4]. The results have been achieved by introducing the indicators of scale economies *SE1* (columns [1] and [3]) and *SE2* (columns [2] and [4]) alternatively.

The sector variables measuring product differentiation and sector concentration are significant in the estimation of the probit model; with regard to the scale economies indicators, *SE1* is highly significant, whereas *SE2* is rejected at the usual significance levels. Thus, large economies of scale affect negatively the probability of existence of intra-industry trade, whereas a certain degree of differentiation is necessary for the appearance of intra-industry trade flows; moreover, the results obtained for *HERF* conforms well to Lancaster's hypothesis. However, none of these variables is significant in the estimation of the OLS model (except *HERF* in equation [3], which cannot be rejected at significance level of 10%); in other words, they do not have any effect on the intensity of these exchanges. These results are consistent with the interpretation we have put forward of the role played by these variables: industry characteristics allow the appearance of two-way trade, but they do not help to explain its share.

On the other hand, country variables are key elements in explaining both why intra-industry trade appears and what share it represents, as all of them are significant in both stages of the process of estimation. Thus, differences in per capita income and market size are significant and have the expected sign, as do average income and average size. Besides we accept the significance of the dummy variables *EU* and *BORDER*. The most striking result, however, is the positive sign obtained for the differences in factor endowments, which contrasts with the predictions of the theoretical model. This outcome appears in other studies when distinguishing supply and demand variables (differences in endowments and differences in preferences, respectively).[24]

Some reasons can be given to explain this result contrary to our expectations. First, it is possible that factors other than capital and labour are relevant to determining comparative advantage, which means increasing the complexity of the relationships involved and departing from the intuitive implications of the simplest models. Another possibility comes from the coexistence of differences in technology (in a

[24] See Bergstrand (1990), Hummels and Levinsohn (1995) and Greenaway *et al.* (1996).

Ricardian sense) jointly with differences in factor endowments as sources of comparative advantage. In this case, if each country employs production-augmenting technologies in those industries in which they lack comparative advantage induced by their endowments, the one-to-one relation between factors relative price and goods relative price may not hold, together with the relation between endowments and inter/intra-industry specialization. On the other hand, differences in relative abundance of human capital can lead to a quite similar effect, as long as they increase the relative efficiency of labour in some countries more than in others. This can change the capital/labour ratios when the latter is measured in homogeneous units. Finally, Helpman and Krugman (1985) argue that when factor-intensity reversals appear, a positive relation can be expected,[25] although this situation does not strictly correspond to the usual Heckscher-Ohlin-Chamberlin framework. Any of the previous statements, or even a combination of them, can explain our results regarding the role of factor endowments. However, the related question whether differences in per capita incomes are only measuring demand aspects remains unsolved. Probably the answer is no, especially when there are more than two productive factors (and, therefore, more sources of comparative advantage) to be considered. Consequently, the results achieved for this variable are perhaps more reliable than those for *DKW*.

5. Concluding remarks

The empirical analysis of the role played by industry and country variables in explaining intra-industry trade has usually provided results more favourable to the latter than the former ones in most cases. In order to provide an explanation of this empirical issue, we have reviewed from a different perspective some aspects of the theoretical models. In this theoretical framework, it can be observed that economies of scale and product differentiation are causes of the appearance of intra-industry trade, although they are non-relevant determinants in explaining the share of intra-industry trade. The assumption that product differentiation is horizontal type is key to this result, both theoretically and (we show) empirically. However, the existence of intra or inter-industry specialization is basically explained by the existence of sources of comparative advantage.

This latter assertion is confirmed by our results, as bilateral variables

[25] See Helpman and Krugman (1985), p. 173.

are found to be significant when they contribute to explaining both the appearance of intra-industry trade flows and their relative level. In all cases we achieve the usual outcome, with horizontal *IIT* increasing with similarities between countries, except in the case of the positive relationship observed for the differences in factor endowments. Apparently, the effect of differences in relative factor endowment we should expect according to the theory is better represented by differences in per capita incomes than by our direct supply variable. If this is what we are really assessing through differences in per capita incomes, we draw the obvious conclusion, and this leads us to take into account additional productive factors in explaining of intra-industry trade, besides physical capital per worker.

Finally, our most interesting outcome refers to sectorial variables. From the estimation of Heckman's model we find in fact that our industry indicators only have a significant effect on the probability of engaging in horizontal intra-industry trade. In this sense, the choice of econometric model is particularly important in clarifying some of the outcomes appearing in previous studies, in relation to the role played by economies of scale and product differentiation. Obviously, it is important to keep in mind that our results have been achieved starting from a set of indicators that can be reasonably criticized, although they arguably rank high among the available ones.

References

Abd-el-Rahman, K. (1991): "Firm's competitive and national comparative advantages as joint determinants of trade composition", *Weltwirtschaftliches Archiv* 12, pp. 83-97.

Aturupane, C., S. Djankov and B. Hoekman (1999): "Horizontal and vertical intra-industry trade between Eastern Europe and the European Union", *Weltwirtschaftliches Archiv* 135, pp. 62-81.

Balassa, B. (1986): "The determinants of intra-industry specialisation in United States trade", *Oxford Economic Papers* 38, pp. 220-233.

Balassa, B. and L. Bauwens (1987): "Intra-industry specialization in a multi-country and multi-industry framework", *Economic Journal* 97, pp. 923-939.

Bergstrand, J.H. (1990): "The Heckscher-Ohlin-Samuelson model, the Linder hypothesis and the determinants of bilateral intra-industry trade", *Economic Journal* 100, pp.1216-1229.

Boskin, M.J., E.R. Dulberger, R.J. Gordon, Z. Griliches and D.W. Jorgenson (1998): "Consumer prices, the consumer price index and the cost of living", *Journal of Economic Perspectives* 12, pp. 3-26.

Caves, R.E., J. Khalilzadeh-Shirazi and M.E. Porter (1975): "Scale economies in statistical analyses of market power", *Review of Economics and Statistics* 5, pp. 133-140.

Clifton, D.S. and W.B. Marxsen (1984): "An empirical investigation of the Heckscher-Ohlin theorem", *Canadian Journal of Economics* 17, pp. 32-38.

Davis, D.R. (1995): "Intra-industry trade: a Heckscher-Ohlin-Ricardo approach", *Journal of International Economics* 39, pp. 201-226.

Ethier, W.J. (1982): "National and international returns to scale in the modern theory of international trade", *American Economic Review* 72, pp. 389-405.

Greenaway, D., R. Hine and Ch. Milner (1994): "Country-specific factors and the pattern of horizontal and vertical intra-industry trade in the UK", *Weltwirtschaftliches Archiv* 130, pp. 78-100.

Greenaway, D., R. Hine and Ch. Milner (1995): "Vertical and horizontal intra-industry trade in the UK", *Economic Journal* 105, pp. 1505-1519.

Greenaway, D. and Ch. Milner (1984): "A cross-section analysis of intra-industry trade in the UK", *European Economic Review* 25, pp.: 319-344.

Greenaway, D., Ch. Milner and R. Elliot (1996): "UK intra-industry trade with EU North and South: a multi-country and multi-industry analysis", CREDIT Research Paper 96/9.

Greenaway, D. and J. Torstensson (1997): "Back to the future: Taking stock on intra-industry trade", *Weltwirtschaftliches Archiv* 133, pp. 249-269.

Harrigan, J. (1994): "Scale economies and the volume of trade", *Review of Economics and Statistics* 76, pp. 321-328.

Heckman, J. (1976): "The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models", *Annals of Economic and Social Measurement* 5, pp. 475-492.

Helpman, E. (1981): "International trade in the presence of product differentiation, economies of scale and monopolistic competition: a Chamberlin-Heckscher-Ohlin approach", *Journal of International Economics* 11, pp. 305-340.

Helpman, E. (1987): "Imperfect competition and international trade: evidence from fourteen industrial countries", *Journal of the Japanese and International Economics* 1, pp. 62-81.

Helpman, E. and P.R. Krugman (1985), *Market Structure and Foreign Trade,* Cambridge: The MIT Press.

Hummels, D. and J. Levinsohn (1995): "Monopolistic competition and international trade: reconsidering the evidence", *Quarterly Journal of Economics* 110, pp. 799-836.

Krugman, P.R. (1979): "Increasing returns, monopolistic competition and international trade", *Journal of International Economics* 9, pp. 469-479.

Krugman, P.R. (1980): "Scale economies, product differentiation and the pattern of trade", *American Economic Review* 70, pp. 950-959.

Krugman, P.R. (1981): "Intra-industry specialization and the gains from trade", *Journal of Political Economy* 89, pp. 959-973.

Krugman, P.R. (1989): "Industrial organization and international trade", in R. Schmalensee and R.D. Willig (eds.), *Handbook of Industrial Organization*, vol II. Amsterdam: North-Holland.

Lancaster, K. (1980): "Intra-industry trade under perfect monopolistic competition", *Journal of International Economics* 10, pp. 151-175.

Leamer, E.E. (1994): "Testing trade theory", in Greenaway, D. and Winters, L.A. (eds.) *Surveys in International Trade*, Blackwell Ltd, Oxford.

Leamer, E.E. and J. Levinsohn (1995): "International trade theory: the evidence", in Grossman, G. and Rogoff, K. (eds.). *Handbook of International Economics*, vol. III. Elsevier Science, B.V. Amsterdam.

Linder, S.B. (1961), *An Essay on Trade and Transformation,* Almqvist & Wiksell, Uppsala.

Loertscher, R. and F. Wolter (1980): "Determinants of intra-industry trade: among countries and across industries", *Weltwirtschaftliches Archiv* 116, pp. 280-293.

Markusen, J.R. (1986): "Explaining the volume of trade: an ecclectic approach", *American Economic Review* 76, pp. 1002-1011.

Nordhaus, W.D. (1998): "Quality changes in price indexes", *Journal of Economic Perspectives* 12, pp. 59-68.

Pagoulatos, E. and R. Sorensen (1975): "Two-way international trade: an econometric analysis", *Weltwirtschaftliches Archiv* 111, pp. 454-465.

Shaked, A. and J. Sutton (1987): "Product differentiation and industrial structure", *Journal of Industrial Economics* 36, pp. 131-146.

Torstensson, J. (1996): "Determinants of intra-industry trade: a sensitivity analysis", *Oxford Bulletin of Economics and Statistics* 58, pp. 507-524.

Resumen

En este trabajo se propone un enfoque nuevo para analizar las principales implicaciones de los modelos de competencia monopolista en relación al comercio intra-industrial (CII). Nos centramos especialmente en dos aspectos: la especificación econométrica más adecuada en relación a la teoría y el papel desempeñado por las variables sectoriales y bilaterales. El análisis se centra en el CII horizontal español con la OCDE durante el periodo 1988-1992. La metodología que adoptamos permite distinguir los efectos que tienen los determinantes del CII tradicionalmente considerados tanto sobre la existencia de este tipo de comercio como sobre su intensidad. Algunas de las ambigüedades que se observan en la literatura en relación con las variables de tipo sectorial no aparecen en nuestros resultados. En este sentido, uno de los resultados más interesantes es la significatividad de las variables sectoriales en la explicación de la existencia del CII horizontal, pero no en su intensidad.

Palabras clave: Comercio intraindustrial, economías de escala, dotaciones factoriales.

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