HORIZONTAL AND VERTICAL INTRA-INDUSTRY TRADE IN THE PROCESSED FOOD SECTOR

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Abstract: For the first time in the food trade literature, the determinants of intra-industry trade (IIT) in horizontally differentiated products and vertically differentiated products are separately tested using the most recent theoretical models of IIT. For both 1980 and 1990, the econometric results confirm country- and industry- specific determinants proposed by these models for explaining horizontal and vertical IIT in the European processed food sector.

Key words: intra-industry trade, horizontal differentiation, vertical differentiation, processed food sector, European Union

Theoretical and empirical contributions to intra-industry trade

The first generation of the monopolistically competitive models for explaining intra-industry trade (IIT) of Krugman (1979, 1980, 1981), Lancaster (1980), Helpman (1981) and Markusen (1986) considers, in addition to scale economies, trade in horizontally differentiated goods that are made up of varieties of a similar quality but different attributes**.** In these models, horizontal differentiation is modeled either with a Chamberlinian "preference for variety" or a Lancastrian preference for an "ideal variety". Extending the theoretical rationales of these first models, Bergstrand (1990) formally shows that the share of bilateral IIT in total trade is a function of inequalities between and average levels of capital-labor endowment ratios, per capita incomes, market sizes and tariff levels. These theoretical models generated a set of empirical studies (Loertscher and Wolter 1980; Greenaway and Milner 1986; Balassa and Bauwens 1987, 1988; Bergstrand 1990;

among others) which**,** using various Grubel-Lloyd (G-L) IIT indices as dependent variables**,** test country- as well as industry-specific determinants of IIT. Results from this first set of empirical studies find some explanatory power for both country and industry determinants, but more so for the former.

The second generation of theoretical models for explaining IIT of Falvey (1981), Falvey and Kierzkowski (1987) and Flam and Helpman (1987), on one hand, and Gakszewicz, Shaked, Sutton and Thisse (1981) and Shaked and Sutton (1984), on the other hand, considers trade in vertically differentiated goods that are made up of varieties of different qualities offering different levels of service. According to the "neo-factor proportions theory" approach of the first set of authors, bilateral IIT in vertically differentiated products results from differences in relative factor endowments, demand for different qualities of the same good and the degree of vertical differentiation. According to the "natural oligopoly" approach of the second set of authors, bilateral IIT in vertical differentiated products is driven by scale economies. This complementary theoretical development to vertical IIT stimulated empirical studies separating trade in horizontally differentiated products (horizontal IIT) and vertically differentiated products (vertical IIT). Following Abd-el-Rahman (1991)**,** who separates total IIT into horizontal and vertical IIT on the assumption that quality is reflected in price and price can be proxied by unit values, Greenaway, Hine and Milner (1994, 1995) respectively test country-specific factors on horizontal and vertical bilateral IIT between the UK and 62 partner countries, and industry-specific factors on horizontal and vertical multilateral IIT between the United Kingdom and all its partner countries. Greenaway, Milner and Elliot (1996) test both country- and industry-specific factors of horizontal and vertical bilateral IIT between the United Kingdom and its ten European partner countries. Results from this second set of empirical studies suggest that determinants of horizontal and vertical IIT differ, sometimes however in

unexpected ways. Measurement errors in the dependent and independent variables may actually lead to biased estimates, particularly for the industrial variables (Greenaway and Torstensson 1997).

Empirical studies of IIT applied to food products are limited in number although IIT is expected to be particularly high in the processed food sector not only due to the importance of innovation, scale economies and horizontal and vertical differentiation typical of this sector but also due to the increased importance of intra-industry specialization vis-à-vis inter-industry specialization as markets integrate and non-tariff barriers vanish as observed in the European Union (EU). With the exception of Henry de Frahan and Tharakan (1997) who disaggregate bilateral food trade flows in flows of homogenous products, horizontal differentiated products and vertically differentiated products, no other empirical study applied to food products distinguishes horizontal and vertical IIT. Using the standard G-L index for measuring total IIT, Christodolou (1992) tests country and industry determinants of bilateral IIT in 1988 for the European meat sub-sector. Hirschberg, Sheldon and Dayton (1994) use a panel study of bilateral total IIT in the food processing sector between 30 countries over the 1964-1980 period to test country determinants only. Henry de Frahan and Libert (1996) examine country as well as industry determinants of bilateral total IIT in 1980 and 1990 for the European food processing sector.

Following Greenaway, Milner and Elliot (1996), this study separates total IIT into horizontal and vertical IIT to test separately the two sets of theoretical models for bilateral food trade between European countries and their major partner countries for 1980 and 1990. Since theoretical models point to different determinants of the two types of IIT, this breakdown allows an accurate test of the specific determinants of horizontal IIT as opposed to those of vertical IIT by removing the misspecification of previous econometric models which have as their dependent variable total IIT.

The remainder of this paper is organized as following. The second section gives the method to separate total IIT into horizontal and vertical IIT and introduces the model specifications. The third section presents the econometric results and their interpretation. The fourth and last section highlights the principal conclusions.

Horizontal and vertical IIT measurement and model specifications

Measuring horizontal and vertical IIT

This study uses unit values as an indicator of product quality following the standard assumption used in international trade empirical studies that relative prices reflect relative quality when estimated at a very disaggregated level, even with imperfect information. Following Abd-el-Rahman (1991), Greenaway, Hine and Milner (1994, 1995) and Greenaway, Milner and Elliott (1996), an arbitrary spread of more than 15 per cent between import and export unit values is used to identify trade flows of products that are vertically differentiated while a spread of less than 15 per cent between import and export unit values is used to identify trade flows of products that are vertically differentiated.[2] By analogy with the calculation of the standard bilateral Grubel-Lloyd IIT index, matched bilateral trade flows of horizontally differentiated products are first calculated at a very disaggregated level of product categories and then summed over all the product categories comprising a particular sub-sector to obtain the numerator of the horizontal bilateral IIT index. Accordingly, matched bilateral trade flows of vertically differentiated products are similarly calculated and summed to obtain the numerator of the vertical bilateral IIT index. These matched bilateral trade flows are then weighted by a denominator which can take two forms. Either, the analyst is interested

[2] Transport and other freight costs alone are assumed not to account for a difference in export and import unit values of more than 15 per cent. Note anyway that the selection of a spread of 15 per cent to distinguish trade flows of horizontally and vertically differentiated products does not dramatically changing the product classification when the range is widened to 25 per cent (Abd-el-Rahman 1991; Greenaway, Milner and Hine 1994, 1995). Note also that for undetermined unit values of exports or imports as a result of unreported exports or imports, bilateral trade flows cannot be classified as bilateral trade flows of either horizontally differentiated products or vertically differentiated products.

in comparing and explaining the share of horizontal and vertical bilateral IIT in total bilateral trade flows within the same sub-sector and uses the total bilateral trade flows of the sub-sector as a common denominator.[3] Or, the analyst is interested in measuring the share of horizontal (vertical) bilateral IIT in trade flows of horizontally (vertically) differentiated products within the same sub-sector and uses the bilateral trade flows of horizontally (vertically) differentiated products of the sub-sector as the denominator. This study uses the first approach of measuring horizontal and vertical IIT while Greenaway, Hine and Milner (1995) and Greenaway, Milner and Elliott (1996) propose the second approach but paradoxically use the first (Tharakan 1997).

Adapting the notation of Greenaway, Hine and Milner (1995) for our study, we measure horizontal bilateral intra-industry trade (HIIT) and vertical bilateral intra-industry trade (VIIT) of EU countries with their major partner countries for the 18 food, drink and tobacco NACE sub-sector as following.[4] First, using the European Nimexe and combined classifications, exports and imports unit values are computed for each pair of partner countries at the sixth or eighth digit level.[5] Using the relative unit values of exports and imports, bilateral trade flows are separated into bilateral trade flows of horizontally and vertically differentiated products. Accordingly, bilateral trade flows of horizontally differentiated products include products *l* where unit values of exports (UV_l^x) and imports (UV_l^m) for a particular dispersion factor ($\alpha = 0.15$) satisfy the condition that:

[3] Note that the sum of horizontal and vertical bilateral IIT is not necessarily exactly equal to total bilateral IIT since for undeterminated unit values of exports or imports bilateral trade flows cannot be classified as bilateral trade flows of either horizontally differentiated products or vertically differentiated products.

[4] The European partner countries are selected in such a way that together they account for more than 80% of the trade volume for most of the individual food products resulting in a sample that includes 22 OECD countries and 18 non-OECD countries. The 40 countries are Australia, Austria, Belgium, Brazil, Canada, China, Cyprus, Czechoslovakia, Denmark, Egypt, Finland, Germany, France, Greece, Hong Kong, Ireland, Israel, Italy, Ivory Coast, Japan, Mexico, Netherlands, Nigeria, Norway, Poland, Portugal, Saudi Arabia, Singapore, South Africa, Soviet Union, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, U.A. Emirates, United Kingdom, USA and Yugoslavia.

[5] In 1988, the combined classification replaced the Nimexe classification. Tables of correspondence exist between these two external trade classifications and the industrial NACE classification (Nomenclature générale des Activités dans les Communautés Européennes).

$$1-\alpha \leq \frac{UV_l^x}{UV_l^m} \leq 1+\alpha$$

with unit values computed per tonne as more widely used in the empirical trade literature.

Similarly, bilateral trade flows of vertically differentiated products include products *l* where:

$$\frac{UV_l^x}{UV_l^m} < 1-\alpha \quad \text{or} \quad \frac{UV_l^x}{UV_l^m} > 1+\alpha \,.$$

Second, horizontal and vertical bilateral IIT indices are computed at the third digit of the NACE classification in a view to use the industry and market characteristics available at this level of NACE disaggregation:

$$IIT_{ijk}^p = \frac{\sum_l \left[\left(X_{ijkl}^p + M_{ijkl}^p \right) - \left| X_{ijkl}^p - M_{ijkl}^p \right| \right]}{\sum_l \left[X_{ijkl} + M_{ijkl} \right]}$$

where *i* refers to countries of origin, *j* countries of destination, *k* food sub-sectors defined at the third digit of the NACE classification, *l* product categories defined at the sixth or eighth digit of the European Nimexe and combined classifications and p denotes horizontally (H) or vertically (V) differentiated products.

Eventually, total bilateral IIT index can be approximated by:

$TIIT_{ijk} = HIIT_{ijk} + VIIT_{ijk}$, ranging between zero and one.

Specifying the HIIT and VIIT models

Theoretical models of horizontal and vertical IIT briefly reviewed above suggest several hypotheses based on the deterministic role of country- and industry-specific factors that we want to test for trade of food products between each of the selected European countries and each of its major partner countries. If relative capital abundance is reflected in relative income per capita, the share of horizontal IIT in total trade volume between two countries is expected to be higher for a smaller difference in per capita incomes and market sizes between the two countries and for a greater average market size and greater average per capita income of the two countries. The share of horizontal IIT in total trade volume is also expected to be higher for a smaller inequality between tariff levels of the two countries and for a smaller taste difference between the two countries, which can be incidently proxied also by the difference in per capita incomes of the two countries according to Linder (1961). If scale economies are reflected in the minimum efficient scale (m.e.s.) of production, the share of horizontal IIT in total trade volume for an industry is expected to be higher for smaller m.e.s. and larger number of firms in the industry, since both elements are associated with more varieties, as well as for greater horizontal differentiation of the products of the industry. Accordingly, the model specification of horizontal IIT is as follows:

$$HIIT_{ijk} = a + b*diffpci_{ij} + c*diffgdp_{ij} + d*avegdp_{ij} + e*avegpci_{ij} + f*eu_{ij} + g*border_{ij} + h*mes_{k} + i*adv_{k} + \mu_{ijk} \quad (1)$$

where

$HIIT_{ijk}$: share of horizontal IIT in total bilateral trade between countries *i* and *j* in industry *k*,

$diffpci_{ij}$: difference[6] in per capita income (pci) between the two countries *i* and *j* reflecting their factor endowment differences, computed from the World Bank's World Tables,

[6] Following Balassa and Bauwens (1987), this is an index independent of the level of pci and varies between zero and one:

$diffgdp_{ij}$: difference[7] in gross domestic product (gdp) between the two countries *i* and *j* reflecting their market size differences, computed from the World Bank's World Tables,

$avegdp_{ij}$: average gross domestic product of the two countries *i* and *j* reflecting their average market size,

$avegpci_{ij}$: average per capita income of the two countries *i* and *j* reflecting their average level of economic development,

eu_{ij}: dummy variable for trade between two EU member countries *i* and *j* which have zero and, hence, similar tariff levels between them,

$border_{ij}$: dummy variable for trade between two neighboring countries *i* and *j* more likely to share similar tastes,

mes_k: minimum efficient plant size reflecting scale economies of industry *k*, measured according to Caves, Khalilzadeh-Shirazi and Porter (1975) for each NACE sub-sector using 1992 United States industrial statistics of the US Bureau of Census for 1990 and 1980 United Kingdom industrial statistics of the UK Central Statistics Office for 1980,

adv_k: ratio of marketing and advertising expenditures on sales reflecting the degree of horizontal differentiation of the products of industry *k*, computed for each NACE sub-sector from the 1977 and 1987 US industrial statistics of the Leading National Advertisers,

μ_{ijk}: random disturbance term.

The expected signs are $b < 0$, $c < 0$, $d > 0$, $e > 0$, $f > 0$, $g > 0$, $h < 0$, $i > 0$.

$diffpci_{ij} = 1 + \frac{w_{ij}\ln(w_{ij}) + (1-w_{ij})\ln(1-w_{ij})}{\ln 2}$ where $w_{ij} = pci_i/(pci_i + pci_j)$.

[7] Computed as indicated in footnote 6.

The share of vertical IIT in total trade volume between two countries is expected to be higher for a greater difference in per capita incomes between the two countries and for a greater average market size of the two countries. The share of vertical IIT in total trade volume for an industry is also expected to be higher for greater vertical differentiation of the products of the industry. For markets with small numbers of firms, the share of vertical IIT in total trade volume for an industry is expected to be higher for larger scale economies, i.e., larger m.e.s. of production. The expected sign, however, stays ambiguous for this industrial characteristic and depends on whether a model of large or small numbers of firms applies (Greenaway, Hine and Milner, 1995). Accordingly, the model specification of vertical IIT is as follows:

$$VIIT_{ijk} = a + b*diffpci_{ij} + c*diffgdp_{ij} + d*avegdp_{ij} + e*avegpci_{ij} + g*border_{ij} + h*mes_{k} + j*hufbauer_{k} + \mu_{ijk} \quad (2)$$

where

$VIIT_{ijk}$: share of vertical IIT in total bilateral trade between countries *i* and *j* in industry *k*,

$hufbauer_{k}$: Hufbauer index[8] reflecting the degree of vertical differentiation of the products of industry *k*, computed for each NACE sub-sector from the European Nimexe and combined classifications,

and all other terms are as in equation 1.

The expected signs are $b > 0$, $d > 0$, $h >$ or < 0, $j > 0$.

The separation of horizontal and vertical IIT tests the empirical robustness of alternative theoretical models for trade in food products.

[8] The Hufbauer index is the variation coefficient of the unit values of the exported products belonging to the same industry.

Econometric results and interpretations

The statistical significance of the determinants of bilateral horizontal and vertical IIT suggested by the theoretical models is tested with a Tobit specification to account for the large number of zero values of horizontal and vertical IIT as in Greenaway, Hine and Milner (1994, 1995) and other empirical studies. To take into account the possibility of a change over time in the influence of each IIT determinant, the test is performed for 1980 and 1990. For 1990, 429 pairs of countries (11 EU countries times 39 partner countries, combining Belgium and Luxembourg into one trading "country") and 18 NACE food sub-sectors (combining NACE 425 and 426) are used, i.e., an initial sample of 7722 observations of bilateral flows for each trade category. For 1980, 312 pairs of countries (8 EU countries times 39 trade partners) and 18 NACE food sub-sectors are used, i.e., an initial sample of 5616 observations of bilateral flows for each trade category.[9]

Table 1 reports the Tobit econometric results for horizontal IIT in 1980 and 1990 while Table 2 for vertical IIT in 1980 and 1990. For both years and dependent variables, the overall explanatory power of the models measured by the correlation squares is relatively low but not far below that other empirical studies. Covering sub-sectors of the same industrial sector, this econometric study uses series of data that probably present less variability than in studies covering different industrial sectors. Econometrics results are similar when using the ordinary and non linear least squares techniques but suffer from non-normality and heteroskedasticity problems. Econometric results are slightly better in terms of statistical significance for 1980 than for 1990.

[9] The COMEXT (EUROSTAT) data base does not provide bilateral trade flows for Greece, Spain and Portugal for 1980. Reciprocal bilateral flows are not discounted.

Table 1: Tobit econometric results for horizontal bilateral IIT in 1980 and 1990

Dependent variable	1980	1990
a	-0.03	-0.05
	(-8.69)	(-17.56)
diffpci	-0.03	-0.35e-02
	(-6.87)	(-1.08)
diffgdp	-0.67e-02	-0.31e-02
	(-2.19)	(-1.44)
avegdp	0.21e-07	0.75e-08
	(8.26)	(8.50)
avepci	0.77e-06	0.20e-05
	(2.47)	(12.89)
eu	0.03	0.02
	(14.22)	(17.39)
border	0.015	0.01
	(6.12)	(9.40)
mes	-0.08	-7.50
	(-4.62)	(-4.73)
adv	0.35e-06	0.19e-06
	(7.00)	(8.28)
Correlation square	0.089	0.119
N	3375	4538

(t-ratio)

Table 2: Tobit econometric results for vertical bilateral IIT in 1980 and 1990

Dependent variable	1980	1990
a	-0.05	-0.08
	(-2.84)	(-5.38)
diffpci	-0.24	-0.08
	(-9.61)	(-5.03)
diffgdp	-0.01	-0.03
	(-1.16)	(-2.85)
avegdp	0.64e-07	0.21e-07
	(5.78)	(4.83)
avepci	0.71e-06	0.35e-05
	(0.51)	(4.60)
border	0.12	0.13
	(11.64)	(16.02)
mes	-0.19	-15.33
	(-2.28)	(-1.95)
hufbauer	0.02	0.01
	(3.26)	(1.88)
Correlation square	0.082	0.096
N	2346	3239

(t-ratio)

With the exception of difference in per capita income (diffpci) taken as a proxy variable to reflect factor endowment differences for vertical IIT, the econometric results are strikingly in line with the theoretical models for both country and industry-specific determinants and better than in other available empirical studies covering different industrial sectors. As expected, the average market size (avegdp) and average level of economic development (avepci) of the two partner countries, their trade preference (eu), their location advantage (border) and horizontal product differentiation of the sub-sector (adv) have a significant positive effect on the level of horizontal IIT while factor endowment (diffpci) and market size (diffgdp) differences between pairs of countries and scale economies of the sub-sector (mes) have a significant negative effect for both 1980 and 1990. These results are all in line with the theoretical models for explaining horizontal IIT. Average market size of the two partner countries (avegdp), their location advantage (border) and vertical product differentiation of the sub-sector (hufbauer) have a significant positive effect on the level of vertical IIT while scale economies of the sub-sector (mes) have a significant negative effect for both 1980 and 1990.

The significant negative sign for the variable proxing scale economies (mes) for horizontal IIT can be interpreted to the extent that scale economies are likely to limit production of horizontally differentiated products, an explanation in line with Caves (1981) and Greenaway, Hine and Milner (1995). The significant negative sign for scale economies (mes) for vertical IIT can in turn be interpreted as reflecting the model of large numbers of firms (Greenaway, Hine and Milner, 1995). The unexpected sign on factor endowment differences between pairs of countries (diffpci) for vertical IIT is not unique to this study. It is also found in Greenaway, Hine and Milner (1994) and Greenaway, Milner and Elliot (1996). Measurement errors in the per-capita income differences (diffpci) used as a proxy variable for factor endowment differences may be a problem in this work

and the work for others in this area. If available, a direct measure of the capital per worker differential between pairs of countries could be, for example, tested to eliminate the demand-side influence of the diffpci proxy variable, as successfully tested in Greenaway, Milner and Elliot (1996).[10]

In sum, the preliminary results presented here cannot be used to support either the "natural oligopoly" approach to vertical IIT for food products, since the proxy variable for scale economies does not have the expected positive sign, nor the Falvey-type factor proportions approach, since the proxy variable for factor endowment differences does not have the expected positive sign. Refining the proxy variables for these two determinants and adding a proxy variable for market structure such as market concentration or number of firms may give some insights on which of the two vertical IIT approaches applies for trade in food products. It is worth noting that all the signs found for vertical IIT are in line with expectations for a horizontal IIT model, an observation also underlined in Greenaway, Milner and Elliot (1996). This finding gives a likely explanation to why the Chamberlin-Heckscher-Ohlin model presented in Helpman and Krugman (1985) which justifies the simultaneous existence of inter- and intra-industry trade on the basis of relative factor endowments, decreasing costs and horizontal product differentiation is successfully tested with total IIT as the regressand. Although the need to test separately determinants of horizontal and vertical IIT is well justified in the new trade theory, this is yet to be empirically confirmed.

[10] The demand-side interpretation of the inequality between countries' per capita incomes suggests that the lower the inequality (i.e., the more similar the consumption patterns are), the higher are trade flows in differentiated goods between the pairs of countries (Bergstrand, 1990).

Conclusions

For the first time in the food trade literature, the determinants of intra-industry trade in horizontally differentiated products (horizontal IIT) and vertically differentiated products (vertical IIT) are separately tested using the most recent theoretical models of IIT. For both 1980 and 1990, the econometric results confirm every country- and industry- specific determinant proposed by these models for explaining horizontal IIT between European countries and their major partner countries. For both years also, the econometric results confirm every country- and industry- specific determinant proposed by these models for explaining vertical IIT between the same partner countries with, however, the exception of per-capita incomes difference taken as proxy variable for relative capital endowments. Correcting measurement errors in the choice of this proxy variable or considering factor endowments more specific to trade in food products such as the relative agricultural basis from which the industrial food sub-sectors get supplies of raw material are possible avenues to test the neo-factor proportions model. Adding a variable for market structure would be an alternative way to test the natural oligopoly approach to vertical IIT.

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