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VERTICAL AND HORIZONTAL INTRA-INDUSTRY TRADE: A CROSS INDUSTRY ANALYSIS FOR THE UNITED KINGDOM*

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A large theoretical literature has emerged directed at explaining the presence of intra-industry trade (IIT). One of the distinctions which comes out of these models is that between horizontal IIT (where goods are differentiated by attributes) and vertical IIT (where goods are differentiated by quality). In this paper horizontal and vertical IIT in UK trade are disentangled using a unit value dispersion criterion and a range of industry characteristics. The paper not only points up the relative importance of vertical and horizontal IIT in the United Kingdom, it also demonstrates how a failure to separate them out can impact on the interpretation of empirical results.

It is now widely recognised that international specialisation need not only take the form of different countries specialising in the products of different industries. Instead all countries may specialise in different types of a given commodity from within the same industry. This intra-industry specialisation results in intra-industry trade (IIT). A great deal of theoretical effort has been expended in explaining the circumstances in which IIT will arise. Besides a range of country-specific determinants this work has shown that scale economies, product differentiation and imperfect competition are typically important. Although the empirical work also confirms that intra-industry trade levels vary with market, production and product characteristics across industries, the results show a degree of inconsistency across studies. (See Greenaway and Milner (1986) for a survey of both the theoretical and empirical work.)

One important distinction in the theoretical literature is between horizontal and vertical product differentiation. The former arises when different varieties of a product are of a similar quality;[1] the latter when different varieties are of different qualities.[2] The importance of the distinction derives from the fact that different industry (and country) characteristics will be associated with trade in the two types of product. As an anonymous referee pointed out, vertical IIT can be related more to traditional theories of comparative advantage whilst horizontal IIT falls much more within the remit of 'modern' theories of trade. Significance also attaches to the distinction because there are good reasons for

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[1] There are two distinct approaches to modelling horizontal differentiation: Lancastrian and Chamberlinian. The former assumes that consumers seek out a particular combination of attributes in their preferred variety; the latter that consumers aim to consume as many varieties of a given product as possible.

[2] Note that a few analysts equate vertical IIT with the exchange of final goods for intermediate goods. The usage of vertical to denote different qualities is more common.

believing that the adjustment implications of a given trade expansion will differ between the two. All of this is well known, but empirically under-researched due to the difficulties of disentangling vertical and horizontal intra-industry trade in the data. In this paper we deploy and develop a methodology which builds upon the work of Abd-el-Rahman (1991) and Greenaway *et al.* (1994), to identify vertical and horizontal intra-industry trade in the United Kingdom, and estimate a model which is aimed at establishing whether industry-specific factors are important in explaining the relative importance of vertical and horizontal IIT in the United Kingdom's trade.

The remainder of the paper is organised as follows: in Section I we briefly review the theoretical literature on vertical and horizontal IIT; Section II describes the methodology used for disentangling vertical and horizontal IIT; Section III sets out the industry specific hypotheses to be tested and Section IV presents the results of that analysis; Section V discusses the implications of the results and concludes.

I. PRODUCT DIFFERENTIATION AND INTRA-INDUSTRY TRADE

From the earliest work on IIT, product differentiation was seen as an important ingredient in its explanation (see for example Balassa, 1967; Grubel and Lloyd, 1975). Following the contributions of Dixit and Stiglitz (1977) and Lancaster (1979) product differentiation has become explicitly modelled in formal analyses of IIT. Dixit–Stiglitz and Lancaster offer alternative representations of horizontal differentiation – the first, the 'love of variety approach', the second the 'favourite variety' approach. These were explicitly incorporated in models of IIT in Krugman (1979) and Lancaster (1979).

Although at the level of the individual agent these approaches are different, with appropriate assumptions regarding the distribution of preferences in the Lancaster case, they yield similar representations in the aggregate. Both demonstrate that horizontal IIT can be associated with preference diversity and decreasing costs. From an empirical standpoint, however, what is important is the interaction of IIT with non-IIT trade, and the factors which explain the relative importance of the two. Here the key contribution is Helpman and Krugman (1985). This can be thought of as a Chamberlin–Heckscher–Ohlin (CHO) model. It incorporates factor endowments, decreasing costs and horizontal product differentiation in a model which generates both intra- and inter-industry trade. It also generates several testable hypotheses based on the deterministic role of country specific factors.[3] The model implicitly also embodies a number of testable hypotheses about industry-specific influences on IIT. The scope for horizontal product differentiation can be expected to vary across industries as the minimum efficient scale (M.E.S.) of production and therefore number of firms vary – a smaller m.e.s. and larger

[3] For example the greater the difference in initial factor endowments the less important will IIT be in their bilateral trade. If in turn relative capital abundance is reflected in relative income per capita one generates the following hypotheses: the greater the similarity in *per capita* incomes between two countries, the greater the share of IIT in their bilateral trade volume; the smaller the difference in market size between two countries, the greater the share of IIT in their bilateral trade; the greater the average market size of countries (in terms of total income), the greater the share of IIT in their total trade.

number of firms being associated with more varieties, and a higher share of horizontal IIT. Although Eaton and Kierzkowski (1984*a*) show that a small numbers case with horizontal differentiation is possible, this is the exception. As the foregoing references indicate, where horizontal differentiation is concerned, large number cases form the dominant paradigm.

Models of vertical IIT date from the seminal contribution of Falvey (1981), followed by Falvey and Kierzkowski (1985) and Shaked and Sutton (1984). In the first two vertical differentiation is explicitly modelled as differences in quality between similar products. Falvey demonstrates that, using a $2 \times 2 \times 2$ structure, one can explain the simultaneous existence of vertical IIT and inter-industry trade, with relatively capital-abundant countries specialising in and exporting relatively high-quality manufactures, whilst relatively labour-abundant countries specialise in low-quality manufactures. Industry specific factors are less precisely defined but are present. There is no role for scale economies but we do have markets with large numbers of firms. Shaked and Sutton (1984) are much more explicit on the role of market structure, with IIT being driven by scale economies which are significant relative to the total market, the result being that a 'natural oligopoly' emerges.

A number of studies have tested for country and industry-specific influences on IIT (Loertscher and Wolter, 1980; Greenaway and Milner, 1984; Balassa, 1986). The empirical work tends to find stronger support for country-specific than industry-specific factors. Nevertheless, total IIT (i.e. in both horizontally and vertically differentiated goods), has been shown to be systematically related to the production and market characteristics of industries. But these results do not disentangle horizontal and vertical IIT despite the fact that theory suggests their determinants will differ. Above we have shown that theory suggests four types of model of IIT in differentiated goods:[4]

- large numbers case of vertical IIT (e.g. Falvey, 1981)
- small numbers case of vertical IIT (e.g. Shaked and Sutton, 1984)
- large numbers case of horizontal IIT (e.g. Helpman, 1981)
- small numbers case of horizontal IIT (e.g. Eaton and Kierzkowski, 1984*b*)

The large numbers case is usually viewed as the dominant form of horizontal IIT and such models give a fairly consistent set of predictions. By contrast, the relationship between vertical IIT and market structure is less clearly defined in the existing literature in part because both large and small numbers cases are plausible and in part because of the intrinsic problems of dealing with small numbers cases. Can the data help us discriminate between these alternatives?

II. DISENTANGLING VERTICAL AND HORIZONTAL IIT

If the relative importance of vertical and horizontal IIT is to be assessed, a satisfactory means has to be found for measuring quality differences in trade.

[4] It is also possible to identify a small numbers case of IIT in homogeneous products (e.g. Brander and Krugman, 1983). Our empirical analysis is targeted at industry structure and horizontal/vertical IIT but not at IIT in homogeneous products.

Hedonic regression has been widely used but is very data-intensive and more appropriate for the analysis of individual product markets rather than a multi-product analysis. In multi-product evaluations of trade flows, quality analysis has been principally undertaken with the use of unit value (UV) indexes which measure the average price of a bundle of items from a given product grouping. The rationale for using UVs is that, assuming perfect information, a variety sold at a higher price must be of higher quality than a variety sold more cheaply. Even with imperfect information, prices will tend to reflect quality (Stiglitz, 1987). In one way or another, all studies of quality in international trade start from the position that, at least at a very disaggregated level, relative prices reflect relative qualities.

In this study, IIT in UK trade with all its partner countries i.e. on a multilateral basis has been calculated at the 5 digit SITC level using the unadjusted Grubel–Lloyd index. IIT has then been divided into horizontal and vertical components using relative unit values of exports and imports, unit values being calculated per tonne.[5] Horizontal IIT was first defined as the simultaneous export and import of a 5 digit SITC product where the unit value of exports (measured f.o.b.) relative to the unit value of imports (measured c.i.f.) was within a range of $\pm 15\%$. Where relative unit values were outside that range, any IIT was considered to be vertical. Abd-el-Rahman (1991) also used this range to distinguish horizontally and vertically differentiated products. Matched trade in each 5 digit SITC product (SITC Sections 5 to 8) was thus categorised as either vertical or horizontal IIT and the amounts of each were summed over all the five digit categories comprising a particular industry.[6] Although $\pm 15\%$ gives us a 'wedge' of 30%, it could be argued that with imperfect information, this is too narrow. In addition, therefore, we have also calculated vertical and horizontal components for a spread of $\pm 25\%$ in unit values. This provides a useful basis for evaluating the robustness of our results.

Thus, intra-industry trade at the third digit level is measured as:

$$IIT_j(3) = 1 - \frac{|X_j - M_j|}{(X_j + M_j)}, \tag{1}$$

where j refers to the jth (SIC) industry. This is the standard Grubel and Lloyd index. Alternatively:

$$IIT_j = 1 - \frac{\Sigma |X_{ij}^p - M_{ij}^p|}{\Sigma (X_{ij}^p + M_{ij}^p)}, \tag{2}$$

where p denotes horizontally (H) or vertically (V) differentiated products, i

[5] Unit values may be computed in several ways e.g. per tonne, or per item. Torstensson (1991) has successfully used unit values per item to analyse the pattern of Swedish vertical intra-industry trade in relation to factor endowments. There are well known problems associated with each (see Torstensson, 1992 for a discussion). However an important point is that sample investigations of UK data suggest that the unit values per item and the unit values per tonne among different source or destination countries tend to be highly correlated, i.e. the variance of average weights per item is relatively low. Unit value per tonne tends to be the more widely used, e.g. by Oulton (1991) in an extensive survey of quality in UK trade 1978–87 and Abd-el-Rahman (1991) in a study of French trade.

[6] The allocation of categories was based on a concordance between the SITC 5th digit and UK Standard Industrial Classification (SIC) digit 3. Details of the concordance are available from the authors on request.

refers to fifth digit SITC products in a given third digit industry, and, as Greenaway and Milner (1983) show, $0 \leqslant IIT_j \leqslant IIT_j(3) \leqslant 1$. In disentangling total IIT (B_j) into vertical (VB_j) and horizontal (HB_j) IIT, we use unit value information, calculated at the fifth digit as follows:

$$B_j = HB_j + VB_j, \tag{3}$$

where HB_j is given by (2) for those products (i) in j where unit values of imports (UV_{ij}^m) and exports (UV_{ij}^x) for a particular dispersion factor (α) satisfy the condition,

$$1-\alpha \leqslant \frac{UV_{ij}^x}{UV_{ij}^m} \leqslant 1+\alpha$$

and VB_j is given by (2) for those products (i) in j where

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

where $\alpha = 0{\cdot}15$ or $0{\cdot}25$.

An industry is defined by the 3rd digit level of aggregation of the United Kingdom SIC (Standard Industrial Classification), which permits use of available data on a comparable basis for industry and market characteristics. Table 1 summarises the evidence on levels[7] of total IIT (B_j), vertical IIT (VB_j)

Table 1

Average Level of Total, Vertical and Horizontal Intra-industry Trade by Manufacturing Industry Group (1988)

	Grubel Lloyd indices (%)							
	Total (%)				Type of differentiation			
					VB_j		HB_j	
SIC industry group	3rd digit B_j (3)	(no of industries)	5th digit B_j	(no of subgroups)	(±15%)	(±25%)	(±15%)	(±25%)
2 Extraction of minerals and ores, manufacture of metals, mineral products and chemicals	80·0	(15)	56·2	(738)	35·0	23·1	21·2	33·1
3 Metal goods, engineering and vehicle industries	81·4	(34)	68·6	(935)	42·7	29·0	25·9	39·6
4 Other manufacturing industries	63·0	(28)	52·3	(674)	41·2	33·8	11·2	18·5
Total (2–4)	74·4	(77)	60·3	(2347)	40·6	29·6	19·6	30·6

and horizontal IIT (HB_j) for a sample of 77 industries for which comprehensive information was available. In the case of total IIT alternative summary

[7] Strictly, Grubel–Lloyd indices of the share of IIT in the gross trade ($X_j + M_j$) of an industry rather than absolute levels are reported.

measures are reported; B_j (3) measures IIT directly at the 3rd digit level, while B_j is a weighted average of the levels of IIT at the 5 digit level.

The average for B_j for all SIC industry groups (2–4) in the sample is high at 60·3 %. Aggregation effects are not expected to be serious therefore, and there appears to be a consistent relationship between the B_j and B_j (3) indices. We use B_j indices in the empirical analysis, because of the consistency that this permits when computing the results for B_j, VB_j and HB_j.

The striking feature of the descriptive information in Table 1 is the fact that VB_j is consistently higher than HB_j for all sub-groups when we use the ± 15 % criterion. For the sample as a whole vertical IIT accounts on average for about two-thirds of total IIT ($\overline{VB}_j$ equals 40·6 % and $\overline{B}_j$ equals 60·3 %). In only 19 out of the 77 industries in the sample is the HB_j index greater than the corresponding VB_j index. Of course this may be fashioned by the size of the unit value dispersion criterion used to distinguish between vertical and horizontal IIT. Thus we also report results for ± 25 %. Predictably the relative importance of vertical IIT declines in some sub-groups. Crucially, however, the average levels of horizontal and vertical are almost the same (29·6 and 30·6 %) and vertical still dominates horizontal in other manufactures (Section III). Thus, the dominance of vertical over horizontal IIT in the United Kingdom's multilateral trade applies for very generous definitions of horizontal IIT.[8]

III. METHODOLOGY

Thus far all empirical testing of industry-specific hypotheses about IIT has related to total IIT (B_j). Many of the models tested have been of the form:

$$B_j = \alpha_0 + \alpha_1 PD_j + \alpha_2 SE_j + \alpha_3 MS_j + \alpha_4 MNE_j + e_j, \tag{4}$$

where PD_j = proxy variable for horizontal product differentiation in industry j; SE_j = proxy variable for scale economies in industry j; MS_j = measure of market structure competitiveness of industry j; MNE_j = measure of the importance of multinational enterprises in industry j.

Following on from the discussion in Section I, *PD*, *SE* and *MS* are included to test for industry-specific factors suggested by models of both horizontal and vertical differentiation. *MNE* is often included because many multi-product firms are also multinational firms and, as Helpman and Krugman (1985) show, there are a number of models where multinational firms are an important deterministic factor where both horizontally and vertically differentiated products are concerned. The expected sign on *MNE* is therefore positive. Note, however, that the expected signs on α_1, α_2 and $\alpha_3 \lesseqgtr 0$. These ambiguities arise because the data do not distinguish between horizontal and vertical product differentiation and because, as we have seen, either may be associated with large or small numbers cases.

[8] The contribution of the cif-fob comparison to the price wedge is ambiguous; the actual price dispersion being greater (lower) where the import fob value is less (greater) than the export fob value. The cif-fob differential is in any case unlikely to account for much of the wedge, especially given that the wedge is being applied to multi- rather than bilateral trade.

Thus although the presence of scale economies of some form is a necessary condition for IIT in most of the theoretical work, it does not follow that IIT in a particular industry is (continuously) positively related to decreasing unit costs. In the present study we relate SE_j to the MES of production. Our preferred hypothesis is that the smaller the MES in an industry the greater the scope for firm entry and product differentiation (i.e. that $\alpha_2 < 0$). Some authors, however, expect plant size to be positively related to IIT. To the extent that MES is small relative to the total size of the industry's market and that the large numbers model is the dominant paradigm, then we would expect that $\alpha_3 > 0$. If, however, market structures with small numbers of firms are the dominant source of IIT then we would expect $\alpha_3 < 0$.

Some of this ambiguity about expected signs disappears if we can separate total IIT into vertical and horizontal IIT. Then we can test the hypotheses presented in Section I with the following equations:

$$VB_j = \alpha_0 + \alpha_1 PD_j + \alpha_2 SE_j + \alpha_3 MS_j + \alpha_4 MNE_j + e_j \tag{5}$$

(the expected signs are $\alpha_1 < 0$, $\alpha_2 \gtrless 0$, $\alpha_3 \lesseqgtr 0$, $\alpha_4 > 0$) and

$$HB_j = \alpha_0 + \alpha_1 PD_j + \alpha_2 SE_j + \alpha_3 MS_j + \alpha_4 MNE_j + e_j \tag{6}$$

(the expected signs are $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_3 > 0$, $\alpha_4 > 0$).

Thus separation of horizontal and vertical differentiation is not only of interest in itself, it facilitates empirical analysis with clearer priors, and allows us to test one theoretical structure against another. In the case of horizontal IIT the ambiguity on the expected signs present in (4) disappears. In the context of large numbers models of IIT we would expect HB_j to be positively related to the extent of attribute differentiation and the lack of concentration of markets and inversely related to the MES. By contrast the ambiguity remains in explaining VB_j (6); α_2 and α_3 have positive or negative signs according to whether a large or small numbers model applies.

Using a SIC/SITC concordance for UK data we estimate these equations. The data definitions and sources for the dependent and independent variables are set out in Appendix 1. The measured levels of IIT relate to the year 1988, using import and export value data taken from OECD data tapes (classified according to the SITC) and measured on a SIC 3 digit basis. All the data for the independent variables in equations 4, 5 or 6 also apply to 1988. All the regression results reported are for a sample of 77 industries and their descriptive statistics are given in Appendix 2. In the case of two of the explanatory variables, alternative proxies were investigated. A measure of market concentration ($CONC_j$) was substituted in some cases for the number of firms measure of market structure (MS_j), opposite signs being expected on these two variables. In the case of (5) a proxy for the degree of vertical product differentiation (VPD_j) was investigated as a replacement for PD_j; again opposite signs are expected on these.

All of the equations and diagnostics were estimated with SHAZAM. Least squares estimation was used in the equations for B_j, VB_j, and HB_j and Tobit estimation was also used for the equation for HB_j (where a number of zero or near zero values for the dependent variable applied). In all cases weighted regressions are reported, to remedy evident heteroskedasticity problems. Net output by each industry (in 1988) was used as the weights (each observation of the dependent and independent variable being multiplied by the square root of the weight variable).

IV. THE RESULTS

The estimated equations for total IIT (B_j) are set out in Table 2. Three equations are reported; (1) using number of firms (MS_j) to capture market structure, (2) using sales concentration ($CONC_j$) as the market structure variable and (3) which includes both MS_j and $CONC_j$ but excludes SE_j.[9] Both produce consistent results and reasonably stable estimated coefficients. The overall explanatory power of both equations is just over 30 %, not unsatisfactory for cross-section work. Except for the alternative specification in (1) which just fails the normality test at the 5 % level, diagnostic tests indicate that we can accept the null hypotheses of homoskedasticity, normality and linearity (at the 5 % level at least).[10]

The results confirm the consensus that has emerged from previous testing of total IIT, namely that large numbers models seem most appropriate in explaining IIT. The sign on MS_j is positive (1) and on $CONC_j$ is negative (2); in both cases with significance at the 5 % level. Similarly the negative sign for α_2, again with strong significance, supports the hypothesis that a relatively small MES permits greater firm entry.[11] The somewhat surprising result is that the sign on PD_j (the attribute diversity proxy) is negative (and with significance at the 1 % level in (2)). This is contrary to earlier evidence including some for the United Kingdom (Greenaway and Milner, 1984), which may suggest that the composition of total IIT (i.e. the relative importance of horizontal and vertical IIT) has changed over time. A growth in the relative importance in vertical IIT in the last decade could account for a switch in the sign on α_1 (from positive to negative). This is not inconsistent with the findings of Oulton (1991) who also uses unit value information and concludes that UK exports in manufactures are predominantly high quality.

What happens when we estimate equations with VB_j and HB_j as dependent variables? In fact we generate results for PD_j which accord with our priors: VB_j and PD_j are inversely related (Table 3) and HB_j and PD_j are positively related (but without significance in the latter case). Moreover, these findings are consistent with both a $\pm 15\%$ and $\pm 25\%$ unit value criterion. We also introduce a proxy for vertical product differentiation (VPD_j), namely the share of non-manual employment in total employment. In other words, we are

[9] An anonymous referee suggested that the average plant size variable (i.e. SE_j) might be scaled relative to industry size in order to capture relative scale economies. In the present context such a proxy is equivalent to MS_j or the number of firms in the industry, i.e. $MS_j = Q_j/SE_j$ where Q_j = net output of industry j.

[10] The only cases of correlation coefficient greater than 0·4 for two RHS variables in any of the results are between VPD_j and MNE_j (0·57) and MS_j and $CONC_j$ (0·46).

[11] An anonymous referee questioned the appropriateness of average size of establishment as a proxy for scale economies, suggesting some kind of scaled variable as an alternative. We estimated a model using a measure of relative value-added (value-added per head in the 5 largest firms relative to that in the other firms in the industry) and again obtain a negative sign albeit without significance.

Table 2

Estimated WLS[1] Regressions for total Intra-industry Trade

Independent variables	Expected sign	Dependent variable (1) B_j	(2) B_j	(3) B_j
(α_0) Constant		64·086 (20·59)***	71·342 (20·69)***	70·820 (15·88)***
(α_1) PD_j	+/−	−0·0748 (−3·435)***	−0·0759 (−3·444)***	−0·0728 (−3·160)***
(α_2) SE_j	−/+	−0·3532 (−4·502)***	−0·2762 (−2·816)***	
(α_3) MS_j	+/−	0·0006 (2·350)**		0·0003 (1·072)
(α_3)′ $CONC_j$	−/+		−0·1480 (−1·922)**	−0·2397 (−3·233)***
(α_4) MNE_j	+	0·1412 (1·334)*	0·1451 (1·343)*	0·1778 (1·577)*
N		77	77	77
$\bar{R}^2$		0·326	0·310	0·246
Diagnostics				
Ramsey Reset Specification test	(F 3, 69)	8·530	8·611	7·056
Jarque Bera Normality test	(χ^2, 2 D.F.)	7·548	6·340	3·442
Harvey Heteroskedasticity test	(χ^2, 4 D.F.)	5·349	6·154	7·651

[1] Weighted least square using net output in each industry (j) as weights.
*** 1% level of significance, ** 5% and * 10%.

assuming that product quality is systematically related to skill intensity. VPD_j also comes out with a highly significant positive sign in (3) and (4) in Table 3. These are important results which may give us a clue as to why so much previous work on IIT and product differentiation appears to have generated such inconsistent results.[12] That inconsistency may reflect the fact that vertical and horizontal IIT differ in their relative importance across different samples.

The separate equations for vertical and horizontal IIT do produce some surprising results, however, for some of the other explanatory variables. Consider first the results in Table 3 for vertical IIT. Note the arrangement of signs on MS_j (in all four equations with a 1% level of significance), on SE_j and on MNE_j (albeit without significance in several cases). Vertical IIT is directly related to the number of firms in the industry; vertical IIT appears to predominate in the large numbers case rather than oligopolistic market structures. The result for SE_j is also consistent with this interpretation of the market structure influences on vertical IIT; a lower MES permitting larger entry and being positively related, therefore, with vertical IIT. Thus referring back to the classification in Section I the combined evidence for MS_j and SE_j does not support the small numbers interpretation of vertical IIT. Finally we find a negative sign with a statistically significant coefficient on MNE_j in (3) and (4) in Table 3. We would have expected a positive relationship, if IIT of

[12] When VPD_j is included, rather than PD_j, in the regression for HB_j the coefficient is insignificant. This further emphasises the differences between the factors driving horizontal and vertical IIT.

Table 3

Estimated WLS[1] Regressions for Intra-industry Trade in Vertically Differentiated Goods

Independent variables	Expected sign	(1) VB_j (±15%)	(2) VB_j (±25%)	(3) VB_j (±15%)	(4) VB_j (±25%)
		Dependent variable			
(α_0) Constant		45·039	36·282	30·736	22·295
		(12·12)***	(9·239)***	(5·438)***	(3·973)***
(α_1) PD_j	−	−0·0848	−0·0439		
		(−3·264)***	(−1·597)*		
(α_1)′ VPD_j	+			0·4009	0·4460
				(2·577)***	(2·887)***
(α_2) SE_j	+/−	−0·1487	0·0048	−0·1090	0·0344
		(−1·587)*	(0·0490)	(−1·137)	(0·3615)
(α_3) MS_j	−/+	0·0013	0·0017	0·0011	0·0015
		(4·231)***	(5·230)***	(3·463)***	(4·683)***
(α_4) MNE_j	+	0·0040	−0·3315	−0·1807	−0·5032
		(0·0317)	(−2·483)***	(−1·299)	(−3·643)***
N		77	77	77	77
$\bar{R}^2$		0·287	0·339	0·251	0·387
Diagnostics					
Ramsey Reset Specification test	(F 3, 69)	3·271	0·340	0·418	0·266
Jarque Bera Normality test	(χ^2, 2 D.F.)	1·536	6·714	2·987	7·993
Harvey Heteroskedasticity test	(χ^2, 4 D.F.)	6·473	1·810	2·324	8·100

[1] Weighted least squares using net output in each industry (j) as weights.
*** 1% level of significance, ** 5% and * 10%.

all types was positively related to the scope for intra-firm trade or if vertical IIT in oligopolistic conditions provided greater scope for rents which attracted greater multi-national involvement.

By contrast when we turn to the results for horizontal IIT in Table 4 we find a positive and highly significant sign on MNE_j in (3) and (4). Of course transfer pricing behaviour may distort the 'true' dispersion between import and export values in the case of intra-firm IIT by multinationals. In which case we must interpret the results on the MNE_j variable in both Tables 3 and 4 with some caution. With respect to the remaining results in Table 4, mixed signs are obtained for attribute differentiation ($\hat{\alpha}_1 \gtrless 0$) but without significance in all cases. The estimated coefficient on SE_j is, as expected, negative (and significant at the 5% level in both equations). This result appears to be consistent with the 'large numbers' model, i.e. with monopolistically competitive market structures generating IIT in horizontally differentiated goods. In contrast, however, the sign on MS_j is negative and significant and is not therefore consistent with the 'large numbers' model of IIT. Indeed one may be inclined to attach greater importance to the result for MS_j than for SE_j, since MS_j is likely to be a more reliable indicator of market structure than SE_j. It is of some interest that the estimated model for horizontal IIT is rather less robust than those for total IIT and vertical IIT; its explanatory power is lower and there

Table 4

Estimated Weighted[1] Regression[2] and Tobit Analysis for Intra-industry Trade in Horizontally Differentiated Goods

Independent variables	Expected sign	(1) HB_j (±15%) (WLS)	(2) HB_j (±25%) (WLS)	(3) HB_j (±15%) (Weighted Tobit)	(4) HB_j (±25%) (Weighted Tobit)
		Dependent variable			
(α_0) Constant		19·048	27·791	1·0817	1·4407
		(4·665)***	(5·941)***	(3·8184)***	(4·9241)***
(α_1) PD_j	+	0·0101	−0·0310	0·0014	−0·0016
		(0·3520)	(−0·9477)	(0·7811)	(−0·8756)
(α_2) SE_j	−	−0·2045	−0·3578	−0·00128	−0·0198
		(−1·987)**	(−3·3035)***	(−1·9399)**	(−2·9579)***
(α_3) MS_j	+	−0·007	−0·0011	−0·0001	−0·001
		(−2·060)**	(−2·829)***	(−2·9929)***	(−2·5930)***
(α_4) MNE_j	+	0·1452	0·4727	0·0092	2·8407
		(1·046)	(2·973)***	(1·0265)	(3·1253)***
N		77	77	77	77
$\bar{R}^2$		0·059	0·220		
Diagnostics					
Ramsey Reset Specification test	(F 3, 69)	2·365	2·749		
Jarque Bera Normality test	(χ^2, 2 D.F.)	8·542	3·648		
Harvey Heteroskedasticity test	(χ^2, 4 D.F.)	0·960	4·696		
Standard error of estimate				17·339	18·173
Log likelihood function				−288·767	−322·125
Squared correlation between observed and expected value				0·084	0·277

[1] Weighted using net output in each industry (j) as weights.
*** 1% level of significance, ** 5% and * 10%.
[2] Weighted least square regression.

are some problems with the diagnostics in the WLS regressions. The dominant explanation of IIT (the 'large numbers' model) seems to fit vertical IIT better than horizontal IIT. Earlier work on total IIT which found support for the large numbers model ascribed this to the prevalence of horizontal IIT; this finding challenges that presumption.

V. CONCLUSIONS

The regression results for vertical and horizontal IIT in Tables 3 and 4 test more carefully the industry-specific hypotheses of IIT than previous econometric work. Previous work has focused on total IIT, despite the fact that theory suggests quite clearly that the determinants of vertical and horizontal IIT differ. We disentangle horizontal and vertical in the data using two alternative criteria, and test for their determinants separately. The results are encouraging in that the explanatory power of at least one of the disaggregated models is comparable to that of the aggregate IIT model. Moreover, the results are also robust to changes in our vertical/horizontal indicator. The levels of significance are also high for many of the estimated coefficients in the disaggregated models. Thus measured levels of vertical and horizontal IIT are systematically related to features of production and industrial structure. Indeed the results indicate that HB_j and VB_j are not necessarily related in the same way to these features of industrial structure. By implication the modelling of aggregate IIT will tend to obscure the true underlying relationships.

There are persuasive *a priori* reasons for separating horizontal and vertical IIT. Theory suggests that their determinants will differ. The empirical evidence presented here supports the view that their determinants do differ but not always in the expected fashion. IIT in vertically differentiated products is not well explained by the small numbers model. Rather we find that vertical IIT is positively related to the number of firms in an industry i.e. the large numbers model applies. Vertical IIT is also positively linked with vertical product differentiation. By contrast there is no evidence of attribute differentiation being positively related to horizontal IIT and this form of IIT seems to be associated with industries with few firms. Earlier evidence on the determinants of total IIT had been interpreted as supporting the 'large numbers' model, on the presumption that horizontal IIT was the predominant form. But this paper challenges this presumption for the United Kingdom. The relative importance of vertical IIT may have been persistently understated but the present work suggests that by 1988 and for the United Kingdom vertical IIT may be the more important type of IIT.

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Appendix 1

Data Definition, Sources and Sample Characteristics

Variable definitions	Data source
(a) Dependent variables	Trade data (X and M in values and quantities) from OECD data tapes, classified according to SITC and recorded at the 5th digit.
B_j = % share of total IIT in gross trade (X_j+M_j) of industry j.	
HB_j = % share of measured horizontal IIT in gross trade of industry j.	
VB_j = % share of measured vertical IIT in gross trade of industry j.	
(where j corresponds with 3rd digit of UK SIC – Industry Groups 2–4).	
(b) Independent variables	
PD_j = number of 5 digit SITC categories in each 3 digit SIC (j)	OECD data tapes
VPD_j = % share of non-manual employment in total employment of industry j	*Business Monitor. Report on the Census of Production*. Summary Volume PA 1002 (1988). Central Statistical Office
SE_j = average size of establishment (net output per establishment)	
MS_j = number of enterprises in 3 digit SIC group	
$CONC_j$ = 5 firm (sales) concentration ratio, i.e. percentage of industry sales of 5 largest enterprises	
MNE_j = % share of total industry sales accounted for by foreign enterprises (in 2 digit group)	

Appendix 2

Descriptive Statistics for Sample

Variable	Mean value	Standard deviation	Minimum value	Maximum value
B_j	60·10	17·53	8·40	90·10
VB_j (±15%)	40·63	16·42	7·10	80·00
VB_j (±25%)	29·58	16·55	3·60	77·70
HB_j (±15%)	19·64	17·23	0·00	70·10
HB_j (±25%)	30·67	21·23	0·00	77·40
PD_j	30·48	38·52	0	297
VPD_j	30·03	10·85	10·00	64·13
SE_j	3·31	12·84	0·09	109·78
MS_j	1586·6	2797·5	24	18688
$CONC_j$	39·18	21·06	9·60	95·60
MNE_j	16·22	12·56	0·01	58·54