EMPIRICAL EXPLANATION OF VERTICAL AND HORIZONTAL INTRA-INDUSTRY TRADE IN THE UK: A COMMENT*

1. Introduction

The pioneering work of Balassa (1967) and Grubel and Lloyd (1975) on the significance and measurement of intra-industry trade (IIT) opened up a substantial literature, both theoretical and empirical.

In recent years, important developments in the literature on intra-industry trade have also stressed that a meaningful distinction – alongside the main division between intra and inter-industry flows – can be drawn between horizontal and vertical components in IIT. This distinction regards the nature of product differentiation. Whereas horizontal differentiation concerns alternative attributes of a particular traded good in a given quality level, vertical differentiation relates to alternative quality levels.

This conceptual specification is important because theoretical models have demonstrated that the forces underlying the two forms of product differentiation within IIT are not the same. Broadly speaking, in the case of vertical IIT (VIIT), the dynamics of product differentiation (by quality) operate according to a Heckscher-Ohlin (HO) logic based on comparative advantages deriving from resource endowments and factor proportions (although there are some non-HO models); in the case of horizontal IIT (HIIT), the typical ingredients of imperfectly competitive market structures play the dominant role.

In spite of these clear indications of the theory, in almost all cases empirical studies investigating the determinants of IIT have

* I am extremely grateful to Alasdair Smith for his precious support in all the stages of this work. I also thank Benedetto Gui, John Hey, Laura Serlenga and two anonymous referees for their helpful comments on a earlier draft. Naturally, all errors are mine.

not distinguished vertical from horizontal intra-industry trade. Only in recent years have some contributions tried to achieve better empirical assessment by adopting methodological procedures able to separate the vertical and horizontal components of IIT.

Greenaway *et al*. (1995) and Greenaway *et al*. (1996) have carried out separate econometric tests for the two components of IIT in the case of the UK, focusing on a range of industry and country determinants of IIT. Overall, the work of Greenaway *et al*. (1995; henceforth GHM) suggests that the approach which distinguishes vertical from horizontal IIT is worth pursuing, given that it enables more accurate interpretation of empirical evidence**.** In particular, their results challenge the idea that the large numbers model of horizontal IIT is the most important explanatory paradigm. However, the evidence reported for the two components of IIT in the case of the UK is not decisive, since it depends closely on the source of data and their level of disaggregation, as well as the methodological criteria adopted.

This paper takes GHM's methodology as its starting point to conduct further investigation of horizontal and vertical IIT in the UK, focusing on the same period considered by GHM (1990). It introduces three innovative features compared to the GHM approach. Firstly, unit values are computed using trade data at a very fine level of product disaggregation, 8-digit as compared to the 5-digit level adopted by GHM, in order to obtain a more reliable proxy for prices and consequently for quality differentiation. Secondly, the share of vertical differentiation in IIT is further divided into two components which are separately tested: the part of vertical IIT composed of flows in which the quality of exports appears higher than the quality of imports; and the remaining part consisting of flows in which exports appear to be of lower quality than imports. As shown below, this further distinction yields a more coherent specification of the expected relationship between quality differentiation and vertical intra-industry trade, though there remain unanswered questions about the explanation of intra-industry trade.

Finally, the determinants of UK intra-industry trade are analysed by distinguishing two geographical groupings, advanced and less advanced countries, in order to test the HO explanation of VIIT appropriately.

While our results cast doubt on the robustness of the econometric estimates of GHM they show that splitting the two kinds of VIIT gives new results which support the GHM's proposition that vertical

intra-industry trade is to be explained in fundamentally different ways from horizontal intra-industry trade.

The paper is organized as follows. The next section discusses the difference between horizontal and vertical product differentiation, conducting a brief survey of the relevant theoretical literature on IIT. Section 3 examines results obtained by Greenaway *et al*. (1995) whose work represents the state of the art of the empirical investigation into horizontal and vertical IIT. Section 4 introduces the two types of vertical IIT and presents an econometric test for the industry-specific determinants of the IIT in the UK, giving details on data, definition of variables, statistical specification and results. The final section makes some concluding remarks.

2. Horizontal and vertical product differentiation in intra-industry trade

2.1 The Dixit-Stiglitz-Krugman Model

Initially, both theoretical explanations of IIT, such as Dixit and Stiglitz (1977) and Lancaster (1980), and empirical investigations, such as Balassa and Bauwens (1987), focused on what has become known as horizontal intra-industry trade (HIIT) - simultaneous export and import of products of the same type and similar quality. The focus both in the theoretical and the empirical work is on the explanation of IIT through the functioning of imperfectly competitive markets in differentiated products.

By extending Dixit and Stiglitz's (1977) closed economy model to the international context, Krugman (1979) demonstrates that the interaction between economies of scale and horizontal product differentiation may be an independent cause of international trade (in the form of IIT) between countries which do not differ in technology or factor endowments.

The Dixit-Stiglitz-Krugman model has dominated the subsequent literature. The assumptions of Krugman's model are straightforward. On the supply side, industry consists of a large number of firms, each producing a particular variety of the product under conditions of increasing returns. On the demand side, individuals appreciate variety in itself, and any new differentiated good available in the market is bound to enter the consumer's basket. In autarky, in each country, the range of varieties available to consumers and the exploitation of economies of scale are both constrained by the

size of the market. International trade will improve the trade-off between variety and scale economies by creating a larger integrated market in which intra-industry specialization between countries may enable firms to reduce unit costs (although in the simplest version of Krugman's model, all firms are of the same size and there are no scale economy benefits from increases in market size), and in which access to a larger number of varieties increases consumer welfare.

The most obvious candidates for the horizontal IIT described by Krugman's model are countries with similar factor endowments and similar (high) income levels, and in such models there may also be an association between demand structure and income level (Linder, 1961) so that countries similar in income level will tend to have more trade between them.

An important implication of this framework is that IIT induces less painful adjustment costs in comparison with inter-industry trade: if products losing market share to import competition and products gaining export markets have similar factor intensities (and are produced in the same sectors), resource reallocation between them will be smoother, and wage and price adjustment will be minor. However, as shown later in this work, this kind of result does not obviously carry over to the case of IIT in vertically differentiated products[1].

2.2 Modelling Vertical Intra-industry Trade

Falvey (1981) and Falvey and Kierzkowski (1987, henceforth FK) presented a model in which intra-industry trade was driven by

[1] However, the analysis of the difference in adjustment costs between IIT and inter-sectoral trade has been little treated in the formal literature. One of the few attempts to model the proposition that IIT adjustment effects on domestic economy are less severe than inter-industry trade has been provided by Krugman (1981). In Krugman's framework, the supply side is modelled with a national economy consisting of two industries, each employing a specific type of labour (which is non-specific among varieties within an industry). By means of a very simple and compact formulation, Krugman shows the existence of a one-for-one positive relationship between the parameter indicating factor endowment similarity (among countries) and the Grubel-Lloyd IIT index. Subsequently, he analyzes the effect of trade on welfare by using a utility function in which utility depends on real wages and variety. Krugman demonstrates that both factors gain from trade when trading partners are similar in factor endowments and consequently IIT prevails over inter-industry trade.

vertical product differentiation, and imports and exports of products within the same commodity classification are distinguished by quality differences. This is vertical intra-industry trade (VIIT). By contrast with the models of horizontal IIT, this is a model which is firmly in the Heckscher-Ohlin tradition in which countries have common tastes and technology, and trade arises from differences in factor endowments of countries and factor requirements of goods. Like the standard Heckscher-Ohlin, the FK model can be adapted to include technological differences between countries. The model differs from the standard textbook HOS model in that factor endowment differences explain intra-sectoral rather than inter-sectoral specialisation: it is a Heckscher-Ohlin model of intra-industry trade.

In FK, the supply side of each economy is modelled as two sectors, one producing a single homogeneous good and the other manufacturing different qualities of the same product. Both sectors employ labour, while capital is used only in the sector producing the multi-quality product, with capital intensity positively correlated with the 'quality intensity' of the differentiated product. On the demand side, consumers have the same preferences, and the demand for each quality, given relative prices, depends on an individual's income: a higher level of income is associated with demand for a higher quality product. On the reasonable assumption of an uneven distribution of aggregate income among consumers, demand for different qualities of product will emerge in the economy, and the range of qualities demanded will depend on income distribution.

Under these assumptions, the actual pattern of trade – with particular reference to the extent and character of vertical intra-industry trade – depends on the relative influence of the three sources of country differences: factor endowments, technology, and income distribution.

The spectrum of relevant cases presented by FK is very broad, and in some circumstances the outcomes are indeterminate. However, in the present context, two main results are worth recalling: one deriving from HO assumptions and the other arising from Ricardian hypotheses.

i) Assuming identical technologies but different factor endowments, the pattern of inter-industry trade is clearly determined: the capital-abundant country will be an importer of the homogeneous good and a net exporter of the differentiated product. In this setting, vertical IIT may or may not take place. Moreover, even if IIT occurs, the pattern of IIT in terms of the quality of traded

goods is indeterminate. Although the capital-abundant country has a comparative advantage in superior quality production, this advantage may or may not be reflected in its exports. Paradoxically, if differences in factor endowments between the two countries are so pronounced as to determine large differences in their levels of *per capita* income, the abundant-capital country (the rich country) may concentrate its exports in lower quality products. In fact, a greater distance between the means of the two countries' equally shaped income distributions reduces their area of overlap, and the poor country will demand low quality products only. Obviously, different results are associated with different assumptions about the form of income distributions in the two countries.

ii) Assuming identical factor endowments but different technologies, the pattern of vertical IIT is determinate: the country with superior technology in the homogeneous good sector will tend to export high quality products and to import low quality goods[2]. In this case, with equal *per capita* income levels between trading partners, (which implies that the country with superior technology in one sector must have inferior technology in the other) consumers in both countries will divide into two groups: a group of high income individuals buying high quality products from the superior technology country, and a group of low income consumers demanding low quality products from the inferior technology country. These results show the way the FK model of vertical IIT combines the Linder-type idea of the importance of the link between demand structure and income with the traditional sources of comparative advantages.

They also show that the distinction between horizontal and vertical IIT is of more than academic interest. As was discussed, intra-industry trade is often assumed to give rise to less painful adjustment effects than inter-industry trade, and this idea has been formalised by Krugman (1981). When similar products with similar factor intensities and from the same industry are exchanged, the factors whose employment is displaced by imports are virtually the same as those whose employment is created by exports. The fact that so much of the growth of intra-European trade is IIT is seen as the explanation for the wide political acceptance of European integration. That is a story which assumes that IIT is horizontal.

---

[2] In fact, in a context of non equalization of factor prices, the higher wage rate of the technologically advanced country will involve a lower capital rental, giving this country a comparative advantage in higher quality products.

But in respect of the adjustment problem, the implications of the FK model are clearly different from those of horizontal IIT models. Unlike horizontal diversification, vertical product differentiation requires different factor intensities. Consequently, the vertical specialization induced by international trade will imply more serious allocating and distributional effects than those of horizontal IIT.

Although the FK model treats the ratio of physical capital to labour as the determinant of the quality of output, Greenaway and Milner (1986) suggested that human capital is more likely to influence output quality than physical capital. Torstensson (1991) and Greenaway and Torstensson (1997) relate the quality of imports (measured by unit values) from partner countries to their endowments of both physical and human capital. Celi and Smith (1999) present a model of vertical intra-industry trade in which it is the ratio of skilled to unskilled labour that determines quality specialisation.

In the FK model tastes for quality are related to income, so income differences between countries can also give rise to trade. In the empirical work in this paper, however, we focus on the relationship between factor endowments and the supply of quality, and ignore the link between consumer income and the demand for quality.

2.3 The Shaked-Sutton Model

An alternative way to deal with vertical differentiation in IIT has been suggested by Shaked and Sutton (1984, henceforth SS). Unlike FK, SS do not examine the interplay between vertical IIT and factor proportions but propose a framework in which attention concentrates mainly on the sensitivity of results to the specification of consumer preferences, in the tradition of product differentiation theory. In particular, they suggest an oligopolistic context in which the opening up of trade is associated with sharper price competition which forces some firms (producing low-quality goods) to abandon the market.

The focus of the SS analysis is on the conditions under which the number of firms existing at Nash equilibrium is bound and independent of the extent of the economy. On the demand side, the willingness to pay for a higher quality product is positively correlated with consumer income. On the supply side, quality improvements are imputable to endogenous fixed costs (R&D expenditure), while unit variable cost rises only slowly with quality. Hence all consumers rank goods in an increasing order of quality at unit variable cost.

In these circumstances, according to the finiteness property derived by SS, the number of firms coexisting at equilibrium is limited, independently of industry size and of the product set. This result is due to price competition: the rivalry among firms producing higher quality goods reduces their prices to a level where all consumers are agreed on buying their products, forcing the lower qualities out of the market. In this mechanism, the role of R&D expenditure is crucial: in order to increase the quality of products, firms spend more in R&D and this limits the number of units in the market. In this oligopolistic equilibrium with a limited number of firms, the opening up of trade does not create a tendency towards the atomistic situation envisaged by monopolistic competition models with horizontal differentiation. On the contrary, the market enlargement associated with free trade induces the exit of firms, given that the initial constraint on the number of units coexisting at equilibrium remains. In the long run, higher returns on R&D investment – in a setting of enhanced economies of scale – will induce the surviving producers to improve their product quality. In this context, the gains from trade for consumers arise from the availability of higher quality goods at lower prices.

3. The results of Greenaway, Hine, Milner, and Elliott

Greenaway *et al*. (1994 and 1995) and Greenaway *et al*. (1996) have built on the work of Abd-el-Rahman (1991) to measure HIIT and VIIT in the UK's trade with the EU and to analyse the different forces underlying the two types of IIT by regression analysis.

Greenaway *et al*. use differences between the unit values of imports and exports of products in the same SITC 5-digit class to distinguish between horizontal and vertical intra-industry trade. (The unit value is defined as the ratio of the value to the weight of a product being traded). If the unit values of imports and exports diverge by more than 15%, this is taken as indicating that imports (M) and exports (X) are of different quality so that there is vertical intra-industry trade; while differences of less than 15% indicate horizontal intra-industry trade. They also present results using a unit-value divergence of 25%, and their results are robust to this change.

Formally, intra-industry trade in industry j is measured using the Grubel-Lloyd index and using disaggregated data on products i within industry j:

$$IIT_j = 1 - \frac{\sum_i |X_i - M_i|}{\sum_i (X_i + M_i)} = \frac{\sum_i (X_i + M_i) - \sum_i |X_i - M_i|}{\sum_i (X_i + M_i)} \tag{1}$$

where the summations are over all commodities i in industry j; while

$$HIIT_j = \frac{\sum_{i \in H} (X_i + M_i) - \sum_{i \in H} |X_i - M_i|}{\sum_i (X_i + M_i)} \tag{2}$$

where the summation i∈H in the numerator is over those commodities for which

$$1 - \alpha \leq \frac{UV_i^x}{UV_i^m} \leq 1 + \alpha \tag{3}$$

and

$$VIIT_j = \frac{\sum_{i \in V} (X_i + M_i) - \sum_{i \in V} |X_i - M_i|}{\sum_i (X_i + M_i)} \tag{4}$$

where the summation i∈V is over those commodities for which

$$\frac{UV_i^x}{UV_i^m} \leq 1 - \alpha \quad \text{or} \quad \frac{UV_i^x}{UV_i^m} \geq 1 + \alpha \tag{5}$$

where the UV_i are the unit values of exports (x) and imports (m). Since the sets V and H are mutually exclusive and exhaustive, it follows immediately that

$$IIT_j = HIIT_j + VIIT_j \tag{6}$$

(The above formulae are spelled out explicitly because there is an apparent notational error in the formulae presented in the Greenaway *et al*. papers).

Greenaway *et al*. (1995) find that VIIT accounts for the greater part of IIT in UK-EU trade in 1988 when the 15% divergence criterion is used, and even with a 25% criterion, VIIT is half of IIT. In cross-industry regressions of IIT variables on a number of explanatory variables they find that there are significant differences in the regressions for HIIT and VIIT, drawing from this the message that the distinction between the two forms of IIT needs to be taken account of in empirical explanations of the phenomenon.

In this paper, we focus particularly on the role of the variables that GHM use to measure product differentiation and we focus on the explanation of VIIT. The variable PD_j ('product differentiation') is the number of 5-digit commodities in the 3-digit industry j. The variable VPD_j ('vertical product differentiation') is the share of non-manual employment in total employment in industry j, and the naming of the variable signals the expectation that because quality

is skill-intensive, vertical product differentiation will be associated with skill intensity. Other explanatory industry variables in GHM measure scale economies, number of firms, and the importance of multinationals.

However, this use of the VPD variable introduces a major methodological issue both for GHM's work and for the work in this paper. If skill-intensity is a determinant of VIIT, that will imply that a skill-abundant country will have a comparative advantage *within each sector* in higher quality products, but it does not necessarily imply that there will be more vertical intra-industry trade in sectors which are more skill-intensive. A good prediction of VIIT across sectors would be a variable which indicated *variance* in quality.

Perhaps surprisingly, the product differentiation variable is insignificant (and of changing sign) in all versions of the GHM regression for HIIT, and while some of the variables which seek to capture imperfect competition are significant they do not tell a consistent story about the model that might explain HIIT – industries with more scale economies tend to have less HIIT, but so do industries with more firms.

In the VIIT equations, the scale economy variable is insignificant, but the market structure variable indicates that industries with more firms have more VIIT. Since there is no theoretical presumption that this should be so, the suspicion must be that this result may arise from imperfect statistical division between HIIT and VIIT.

There is a significant negative relationship between PD and VIIT – industries with a wider range of products have less VIIT, which GHM indicate coincides with their theoretical presumption, though they do not explain this presumption. Arguably, the wider the product range, the more scope there is for all forms of IIT which would suggest a positive relationship between PD and VIIT. More interestingly, when PD is replaced by VPD in the regression for VIIT, the coefficient is positive and highly significant: industries with a high proportion of non-manual workers do have a strong tendency to have a high level of VIIT. By implication, sectors with a high proportion of non-manual workers have a high variance in product quality. Thus GHM conclude that it is important in empirical work to separate vertical and horizontal IIT.

Greenaway *et al*. (1996, henceforth GME) extend the GHM analysis to include country-specific effects and therefore run regressions across countries and across industries.

The country-specific variables they investigate include capital

stock per worker, and their regression equation for VIIT with all EU countries, again for 1988, that has both capital stock per worker and non-manual share in industry employment has significant positive coefficients for both variables: there is more VIIT with countries that have different levels of capital per worker and in industries that have more non-manual workers.

These relationships are, however, not stable: a regression for VIIT confined to EU 'North' countries has an insignificant (negative) coefficient on the capital stock variable while keeping the significant positive coefficient on the non-manual employment share in industry. The VIIT regression for EU 'South' countries has non-significant coefficients on both of these variables.

4. Introducing two types of vertical intra-industry trade

4.1 Methodology

There is a difficulty in the interpretation of the results that GHM and GME obtain about the relationship between VIIT and factor endowment and factor intensity variables: such results are supportive of the general idea that VIIT has a Heckscher-Ohlin explanation, but the GHM and GME regressions are not well designed to elicit convincing evidence. The problem is that we should not expect VIIT to be monotonically related either to country characteristics or to industry characteristics. A country would be expected to have a comparative advantage in skill-intensive or capital-intensive products in trade with countries compared to which it is well endowed with human or physical capital, and for a given set of trading partners we should expect to see different forms of VIIT in different sectors. The theory provides explanations for the dissection of VIIT within sectors rather than the distribution of VIIT across sectors.

We therefore here distinguish between two types of VIIT: 'upwards' vertical IIT in which the country is an exporter of higher quality products, $VIIT^{+}$; and 'downwards' vertical IIT in which the country is an exporter of lower quality products, $VIIT^{-}$. The formal definitions follow very naturally from equations (2) and (4) in the previous section. For sector j:

$$VIIT_j^{+} = \frac{\sum_{i \in U}(X_i + M_i) - \sum_{i \in U}\left|X_i - M_i\right|}{\sum_i (X_i + M_i)} \tag{7}$$

where the summation $i \in U$ is over those commodities for which

$$\frac{UV_i^x}{UV_i^m} \geq 1+\alpha \tag{8}$$

while

$$VIIT_j^- = \frac{\sum_{i\in D}(X_i + M_i) - \sum_{i\in D}|X_i - M_i|}{\sum_i (X_i + M_i)} \tag{9}$$

where the summation $i \in D$ is over those commodities for which

$$\frac{UV_i^x}{UV_i^m} \leq 1-\alpha \tag{10}$$

Since the sets U and D are mutually exclusive and exhaustive of V, (1.6) now becomes

$$IIT_j = HIIT_j + VIIT_j^+ + VIIT_j^- \tag{11}$$

Empirical investigation of the significance of the distinction between upward and downward vertical IIT has been undertaken using different data from GHM and GME. Our industries are the 3-digit NACE industries of the UK on which statistics are obtained from the European Commission's INDE database. Commodity level trade data at the 8-digit level comes from the Commission's COMEXT data. The COMEXT databank includes a concordance with the NACE industrial classification, so from COMEXT data, in accordance with the formulae set out above and assuming $\alpha = 0.2$, it is possible to derive statistics at industry level for HIIT, $VIIT^+$ and $VIIT^-$ (see Appendix for more details).

The use of 8-digit commodity data has the advantage that at this more disaggregated level, one can have more confidence that unit value differences genuinely reflect quality differences in otherwise similar products[3]. For example, the 8-digit CN code 84182199 refers to 'Household refrigerators, compression type, capacity between 250 and 340 litres, excluding table models and building-in types', one of 68 products which correspond to the 3-digit NACE sector 'domestic electrical appliances', whereas the SITC 5-digit code 77521 covers all of 'Refrigerators, household type (electric or other), whether or not containing a deep-freezer compartment'. At the 5-digit level, UV differences might reflect the fact that refrigerators of quite different kinds were being imported and exported rather than being a reliable indicator of quality differences. By contrast, with the narrow 8-digit product definition, UV differences would properly signal quality

[3] Here unit values are calculated as the ratio between the value of the trade flow (import or export of the 8-digit commodity) and its weight. The consistent use of supplementary units for volumes was not possible because such data are not comprehensive.

differences between imported and exported refrigerators of this particular specification. Given the disaggregated level of calculation, it would be more appropriate to use the term 'intra-product trade' than 'intra-industry trade', but we shall retain the conventional terminology. It is, however, necessary to remember that the statistics with which we are working are of *sectoral* levels of intra-product trade.

From our data sources, the variables shown in the list below were derived for each 3-digit NACE sector ('industry *I*') for the UK. Thus in addition to the IIT indices we have three variables (SCA, COMP, SUBSE) associated with market structure and two (SKUN, KL) which are associated with factor endowments. (Unlike GHM, we do not include a variable for the importance of multinational enterprises in a sector but we add in a proxy for innovation).

Variable	Name	Definition
IIT_i	Index of total intra-industry trade	eqn (1)
$HIIT_i$	Index of horizontal intra-industry trade	eqn (2)
$VIIT_i$	Index of vertical intra-industry trade	eqn (4)
$VIIT^+_I$	Index of up-market VIIT	eqn (7)
$VIIT^-_I$	Index of down-market VIIT	eqn (9)
SCA_i	Scale economies	turnover per unit
$COMP_i$	Competition	number of units in sector
$SUBSE_i$	Horizontal differentiation	number of 8-digit CN products in 3-digit NACE sector
$SKUN_i$	Skill-intensity	ratio of non-manual to manual workers
KL_i	Capital intensity	ratio of investment to employment
$INNOV_i$	Innovation	ratio of investment to value-added

The specification adopted by GHM for total IIT is a standard specification adopted in many tests of industry-specific determinants of intra-industry trade:

$$IIT_i = \alpha_0 + \alpha_1 SUBSE_i + \alpha_2 SCA_i + \alpha_3 COMP_i + e_i \qquad (12)$$

where the expected signs of estimated coefficients α_1, α_2 and α_3 would be ambiguous for the reason that total IIT includes both forms of product differentiation and large or small numbers cases.

Equation (12) can be estimated separately for HIIT and VIIT:

$$HIIT_i = \alpha_0 + \alpha_1 SUBSE_i + \alpha_2 SCA_i + \alpha_3 COMP_i + e_i \qquad (13)$$

$$VIIT_i^- = \alpha_0 + \alpha_1 SUBSE_i + \alpha_2 SCA_i + \alpha_3 COMP_i + e_i \qquad (14)$$

Now, we should expect differences in the explanation of HIIT and VIIT. At this stage, following GHM, such diversity should be reflected in the signs of coefficients.

In accordance with GHM's preferred explanation for HIIT, in the equation (13) the expected signs of estimated coefficients would be $\alpha_1 > 0$, $\alpha_2 < 0$, $\alpha_3 > 0$, reflecting the expectation that more horizontal IIT will be associated with more horizontal product differentiation, smaller firms and more firms per industry.

By contrast, in the case of VIIT, the expected signs of estimated coefficients would be $\alpha_1 < 0$, $\alpha_2 \gtreqless 0$, $\alpha_3 \gtreqless 0$. In equation (14) the signs of the scale and competition variables are ambiguous because the large group (FK) and small group (SS) explanations of vertical product differentiation give different predictions. The negative sign for α_1 follows GHM's assumption though we have already expressed doubts about this assumption.

Again, following GHM's preferred specification for VIIT, we replace the variable for horizontal product differentiation with the skill-intensity variable. It also turns out that there is a strong statistical case for the inclusion of the capital-intensity variable, giving the equation:

$$VIIT_i = \alpha_0 + \alpha_1 SKUN_i + \alpha_2 SCA_i + \alpha_3 COMP_i + \alpha_4 KL_i + e_i \qquad (15)$$

GHM expect a positive sign for α_1 on the basis of the FK explanation of VIIT in Heckscher-Ohlin terms. The expected sign of α_1, however, needs to be carefully considered. VIIT is defined as the exchange of high-quality for low-quality goods within a sector, and quality is hypothesised to be related to skill-intensity. As we have already argued, we would expect the volume of VIIT to be relatively high in sectors within which there was high *variance* in the skill-intensity of production of product varieties. But we have no data on this.

We also need to recall, as Leamer (1984) has emphasised, that the Heckscher-Ohlin approach requires data on factor intensities of production, factor endowments of countries, and trade flows, so a Heckscher-Ohlin account relating the trade flows of the UK to the characteristics of sectors requires also some account of some assumptions about the factor endowments of the UK relative to the relevant trade partners.

If the UK is well-endowed with skill (capital) and if high quality goods are more skill-intensive (capital-intensive) than low-quality goods, then we would expect the UK to have a comparative advantage in skill-intensive (capital-intensive) sectors *and* within these sectors to be a net exporter of high quality goods, and we would observe an association across sectors between 'up-market' VIIT and the skill-intensity (capital-intensity) of production. We would not expect to observe much 'down-market' VIIT, and its relationship to the skill-intensity (capital-intensity) of production is unpredictable.

Therefore with up-market and down-market VIIT separately identified, we have two equations:

$$VIIT_i^+ = \alpha_0 + \alpha_1 SKUN_i + \alpha_2 SCA_i + \alpha_3 COMP_i + \alpha_4 KL_i + e_i \quad (16)$$

$$VIIT_i^- = \alpha_0 + \alpha_1 SKUN_i + \alpha_2 SCA_i + \alpha_3 COMP_i + \alpha_4 KL_i + e_i \quad (17)$$

where the expected sign of estimated coefficients for SKUN and KL would be positive in equation (16) and ambiguous in equation (17).

In this chapter, the equations illustrated above have been estimated for the UK in 1990 by carrying out standard OLS cross-section regressions on 63 observations (industrial sectors)[4]. UK intra-industry trade has been analysed with regard to two geographical groupings: advanced countries (ACs) and less advanced countries (LACs)[5]. The separation of advanced countries from less advanced countries is crucial in order to test factor proportion explanation of VIIT appropriately.

4.2 Total Intra-industry Trade

Since the theoretical presumptions discussed in the previous section are somewhat tentative, it is important to explore the full range of possibilities. We therefore follow the procedure of starting from a common specification with all regressors inside and then by dropping out insignificant variables systematically and one at a time. We report the best specification for each geographical grouping. Whenever heteroskedasticity problems occur, the reported OLS estimates are based on adjusted White heteroskedasticity-consistent standard errors. In all regressions, logarithms of variables are considered.

Table 1 illustrates the regression results for total IIT. If we look at UK-ACs trade, the best results are obtained when IIT is

---

[4] The sectors included are the 3 digit sectors from NACE 26 onwards (thus not including the extraction and chemicals industries). A number of sectors (17) have been excluded because of missing data.

[5] Less advanced countries (LACs) comprise all of the rest of the world except the EU, EFTA, the USA, Canada, Japan, Australia and New Zealand. The LACs are not quite the same as non-OECD countries: they include Turkey and the countries which joined the OECD in the 1990s. It is a wider category of countries than 'less developed countries' as usually defined, because of the inclusion of East European countries, all of Latin America and even the most advanced of the South East Asian countries.

TABLE 1 - *Industry Specific Determinants of UK Total Intra-industry Trade. 1990*

Dependent variable: IIT[a]	OLS				Observations 63			Diagnostics:		
Regressors[a]	Constant	SUBSE	SKUN	SCA	COMP	KL	INNOV	Function form[b]	Normality[c]	Heteroskedasticity[d]
ACs trade										
	-5.712	-0.126	0.744	0.183	0.198	-1.494	1.026	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.31	(-3.12)***	(-1.53)	(1.35)	(-1.37)	(2.72)***	(-1.80)*	(1.20)	4.83	286	1.21
	-3.422				0.133	-0.337		F(1, 59)	CHI-SQ (2)	F(1,61)
R^2: 0.23	(-5.24)***				(2.21)**	(-2.85)***		0.86	243	1.65
LACs trade										
	-8.231	-0.334	1.937	0.124	0.383	-3.425	3.667	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.40	(-2.83)***	(-2.55)***	(2.22)**	0.58	(3.30)***	(-2.60)***	(2.70)***	10.78	106	0.166
	-6.765	-0.320	1.808		0.359	-3.013	3.274	F(1, 56)	CHI-SQ (2)	F(1,61)
R^2: 0.39	(-4.70)***	(-2.50)***	(2.16)**		(3.33)***	(-2.74)***	(2.80)***	9.00	110	0.12

[a] Logarithms of variables. [b] Ramsey's RESET test. [c] Based on a test of skewness and kurtosis of residuals. [d] Based on the regression of squared residuals on squared fitted values.
*** 1% level of significance, ** 5% and * 10%.

regressed on COMP and KL. The positive sign on COMP (the market structure variable) and the high level of significance associated with factor intensity variable KL (but with negative coefficient) may indicate that total IIT pattern is driven by vertical IIT, particularly in the form of large numbers model. In the case of UK-LACs trade, the impression that IIT is dominated by the large numbers models of vertical IIT is even stronger: now the best specification includes all factor intensity variables (SKUN, KL, INNOV*)* and two market structure variables (COMP with positive sign and SUBSE with negative sign). The positive sign on SKUN is a result in line with equation (16) for up-market vertical intra-industry trade, although the negative sign on KL does not entirely bear out this interpretation.

In the end, the general picture that emerges from this first set of regressions seems to contrast with the traditional conviction – as it emerges from previous empirical studies – that horizontal intra-industry trade is the dominant form of IIT. On the contrary, the negative sign on SUBSE and the significance associated with factor intensity variables (especially KL) suggest that the pattern of IIT is driven by vertical intra-industry trade. Except for the inclusion of HO variables, on the whole this first set of regressions on total IIT yields an outcome reasonably in line with the estimates of Greenaway *et al*. (1995).

We now follow GHM and separate horizontal and vertical IIT. If we look at the IIT indices computed at the 8-digit level across all sectors in Table 2, the UK trade with ACs divides into 30.1% VIIT and 20.8% HIIT, while the UK trade with LACs divides into 19.4%

TABLE 2 - *UK Total, Horizontal and Vertical Intra-industry Trade. Grubel-Lloyd indices (%)*[a] *1990*

	IIT	HIIT	VIIT	$VIIT^{+}$	$VIIT^{-}$
UK-WORLD trade	55.0	22.0	33.0	20.0	13.0
UK-ACs trade	50.9	20.8	30.1	16.2	13.9
UK-LACs trade	21.9	2.5	19.4	16.1	3.3

[a] Calculated at 8-digit level across 63 manufacturing sectors and 5401 subgroups.

VIIT and 2.5% HIIT, and the UK's total trade divides into 33% VIIT and 22% HIIT. In all cases, VIIT is the largest part of trade flows and this suggests that it is worth to test the determinants of IIT separately for the VIIT and HIIT.

4.3 Horizontal Intra-industry Trade

Table 3 displays the results of the HIIT estimates. As expected, LACs trade is poorly determined in comparison with ACS trade. In other words, HIIT is better explained in a context of non-HO trade and this result confirms that it is useful to carry out separate estimates for the two geographical groupings. However, in UK trade with ACS, only one market structure variable is significant (COMP). The positive sign on COMP seems to be in line with the large numbers model of HIIT. On this regard, our results contrast GHM's results. In GHM's estimates for HIIT, an unexpected negative sign on COMP combined with an insignificant coefficient for SUBSE (the specific proxy for horizontal differentiation) led them to consider the estimated equation for HIIT to be less robust than those for IIT and VIIT.

While our results for HIIT differ from those of GHM, the general message is somewhat similar – of weak statistical results not entirely in line with theoretical expectations (market structure variables, like SCA and SUBSE, which are crucial for the explanation of HIIT, are insignificant). In interpreting the weakness of our results for HIIT, it needs to be remembered that IIT is here being measured at a very disaggregated level: what we have found is the absence of any relations across 3-digit sectors between the characteristics of the sectors and the level of intra-product trade within sectors. The adoption here of a disaggregation at the product level may explain why our results for HIIT are unsatisfactory. In effect, as discussed above, the 8-digit level is appropriate to measure VIIT because one can have more confidence that unit value differences genuinely reflect quality differentiations in otherwise similar products. But, at the same time, the disaggregation at the product level (8-digit) risks the loss of information about attribute differentiation in HIIT. Recalling the previous example, at the 5-digit level we identify the exchange of refrigerators with or without freezer. This type of trade reflects genuinely the exchange of similar goods differentiated by attribute (in this case, the presence or not of the freezer), that is HIIT. In choosing a level of disaggregation more appropriate to the identification of VIIT, we are losing a substantial amount of HIIT. So a possible reason of our unsatisfactory estimates for HIIT could be imputed to the level of disaggregation.

4.4 Vertical Intra-industry Trade

As Table 4 shows, more robust results emerge for VIIT. In the

TABLE 3 - *Industry Specific Determinants of UK Horizontal Intra-industry Trade. 1990*

Dependent variable: HIIT[a]	OLS				Observations 63			Diagnostics:		
Regressors[a]	Constant	SUBSE	SKUN	SCA	COMP	KL	INNOV	Function form[b]	Normality[c]	Heteroskedasticity[d]
ACs trade										
	-13.259	-0.107	2.197	0.472	0.376	-4.703	5.267	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.24	(-2.87)***	(-0.52)	(1.59)	(1.40)	(2.05)**	(-2.25)**	(2.45)***	3.13	139	1.94
	-5.966				0.330	-0.959	1.531	F(1, 59)	CHI-SQ (2)	F(1,61)
R^2: 0.23	(-3.54)***				(2.12)**	(-1.96)**	(2.12)**	2.44	174	0.76
LACs trade										
	-16.992	0.121	3.035	0.509	0.472	-5.551	6.461	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.20	(-2.57)***	(0.41)	(1.53)	(1.05)	(1.79)*	(-1.85)*	(2.09)**	2.69	4.49	1.25
	-7.137					-1.346	2.370	F(1, 59)	CHI-SQ (2)	F(1,61)
R^2: 0.08	(-2.89)***					(-2.01)**	(2.31)**	3.18	5.7	1.43

[a] Logarithms of variables. [b] Ramsey's RESET test. [c] Based on a test of skewness and kurtosis of residuals. [d] Based on the regression of squared residuals on squared fitted values.
*** 1% level of significance, ** 5% and * 10%.

case of UK trade with advanced countries, the best specification has SKUN, COMP and K*L* as explanatory variables. An alternative specification includes SCA as explanatory variable in place of SKUN (see the third row of Table 4). In the case of UK trade with LACs, the best result emerges when SUBSE and SC*A* are dropped out from the initial common specification and VIIT is regressed on SKUN, COMP, KL and INNOV. So, in a context of HO trade (UK trade with LACs), all factor intensity variables are significant when VIIT is tested. Again, the sign on coefficient estimated for COMP (+) seems to support the large numbers model of vertical intra-industry trade.

GHM attach great importance to the negative expected sign on the horizontal differentiation variable in estimated equation for VIIT (SUBSE here and PD_j in GHM), but in our results the factor intensity variable KL performs better than SUBSE (KL is highly significant in all regressions for VIIT).

The inverse relationship between VIIT and capital-intensity is not so surprising if we look at characteristics of sectors; data reveals that the most capital-intensive industries are those with less scope for product differentiation: chemical and food processing (brewing and malting, sugar manufacturing and refining, grain milling, etc.)[6]. In effect, the negative sign on KL does not support an Heckscher-Ohlin story of vertical intra-industry trade, but we argued earlier that once factor-intensity variables are brought in to the explanation of VIIT, it is desirable to look separately at the up-market ($VIIT^+$) and down-market ($VIIT^-$) components of VIIT. Of the UK trade with ACs, 30.1% is VIIT at the 8-digit level and that divides more or less equally into 16.2% up-market and 13.9% down-market. In UK-LACs trade, the 19.4 % total of 8-digit VIIT is 16.1% up-market and 3.3% down-market. For total trade, 33% is VIIT, of which 20% is up-market and 13% down-market (see Table 2).

Tables 5 and 6 show the statistical results for $VIIT^+$ and $VIIT^-$ respectively.

Comparing Tables 5 and 6, we see quite different results for the two forms of VIIT. If we look at UK up-market VIIT with advanced countries, regression results are quite consistent with the large numbers model of vertical intra-industry: UK has a comparative

[6] The rank of the first ten 3 digit sectors with higher values of KL is: 427, 260, 425, 411, 428, 424, 420, 416, 351, 371 (for the description of sectors, see table 1A in Appendix).

TABLE 4 - *Industry Specific Determinants of UK Vertical Intra-industry Trade. 1990*

Dependent variable: VIIT[a]	OLS				Observations 63			Diagnostics:		
Regressors[a]	Constant	SUBSE	SKUN	SCA	COMP	KL	INNOV	Function form[b]	Normality[c]	Heteroskedasticity[d]
ACs trade										
	-6.682	0.155	0.768	0.164	0.196	-1.097	0.346	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.20	(-2.24)**	(1.16)	(0.86)	(0.75)	(1.65)*	(-0.81)	(0.24)	0.22	286	3.41
	-4.349		0.635		0.211	-0.658		F(1, 58)	CHI-SQ (2)	F(1,61)
R^2: 0.17	(-4.16)***		(1.92)**		(2.18)**	(-2.48)***		0.12	601	0.12
	-6.981			0.284	0.269	-0.587		F(1, 58)	CHI-SQ (2)	F(1,61)
R^2: 0.16	(-3.63)***			(1.74)*	(2.49)***	(-2.34)**		0.08	484	0.16
LACs trade										
	-9.563	0.034	2.077	-0.131	0.234	-3.388	2.939	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.33	(-2.40)**	(0.19)	(1.74)*	(-0.45)	(1.47)	(-1.88)*	(1.58)*	6.86	205	2.662
	-11.055		2.206		0.264	-3.819	3.358	F(1, 57)	CHI-SQ (2)	F(1,61)
R^2: 0.33	(-5.89)***		(1.94)**		(1.93)**	(-2.56)***	(2.12)**	7.05	230	2.05

[a] Logarithms of variables. [b] Ramsey's RESET test. [c] Based on a test of skewness and kurtosis of residuals. [d] Based on the regression of squared residuals on squared fitted values.
*** 1% level of significance, ** 5% and * 10%.

advantage in high quality products in skill-intensive sectors and in industries where there are many firms (but where the capital intensity is lower). But this is not the case when we look at UK down-market VIIT with advanced countries: now COMP and SKUN are insignificant and $VIIT^-$ is explained only by the proxy variable for horizontal differentiation (SUBSE, but with the sign expected for HIIT) and capital intensity (KL). More robust results emerge when we look at UK-LACs trade. In this HO context, $VIIT^+$ is explained by all factor intensity variables (SKUN, KL, INNOV) and by the market structure variable indicating the number of firms (COMP, with positive sign). This result is in line with the large numbers model of VIIT. But, when we look at UK down-market VIIT with LACs the picture becomes less consistent with the large numbers model: now the proxy variable for economies of scale is significant but with positive sign. In general, results show the importance of dividing VIIT in up-market and down-market flows, although it is not easy to offer a fully consistent interpretation of the picture. In addition, the separation of vertical intra-industry trade into $VIIT^+$ and $VIIT^-$ components makes more clear the geographical differentiation of the UK pattern of VIIT.

To sum up the picture emerging from OLS estimates for VIIT, let me recall results variable by variable.

KL is a significant variable (with negative coefficient) for all version of VIIT. Since VIIT should be explained by the variance in quality within sectors, this seems to imply that capital-intensive sectors have less vertical product differentiation. In effect data reveals that capital-intensive sectors are those producing more standardised industrial products.

COMP is a significant variable for all versions of VIIT, but only when we look at UK-LACs trade. In fact, in the case of UK-ACs trade, it is significant in the case of $VIIT^+$, but not for $VIIT^-$. As already argued, this result shows the importance of separating $VIIT^+$ from $VIIT^-$.

Again, the division of VIIT in up-market and down-market components turns out to be useful when the role of economies of scale are investigated. *SCA* is significant only in the case of UK-LACs $VIIT^-$ (with positive impact). These effects, revealing also the geographical differentiation of UK VIIT, are much less clear when VIIT is not disaggregated.

SUBSE has not the negative impact which GHM expect: in the only case in which it turns to be significant (UK-ACs $VIIT^-$), it has a positive impact.

TABLE 5 - *Industry Specific Determinants of UK Up-market Vertical Intra-industry Trade. 1990*

Dependent variable: VIIT+[a]	OLS				Observations 63			Diagnostics:		
Regressors[a]	Constant	SUBSE	SKUN	SCA	COMP	KL	INNOV	Function form[b]	Normality[c]	Heteroskedasticity[d]
ACs trade										
	-6.756	0.019	1.084	0.143	0.189	-1.504	0.865	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.15	(-2.14)**	(0.13)	(1.14)	(0.62)	(1.49)	(-1.05)	(0.59)	0.40	147	0.37
	-4.630		0.648		0.184	-0.642		F(1, 58)	CHI-SQ (2)	F(1,61)
R^2: 0.14	(-4.25)***		(1.88)*		(1.83)*	(-2.33)**		0.42	174	0.04
LACs trade [e]										
	-10.244	0.001	2.641	-0.291	0.225	-4.274	4.027	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.36	(-2.48)	(0.004)	(2.07)**	(-0.88)	(1.23)	(-2.27)**	(1.99)**	3.75	26.46	4.15
	-13.787		2.958		0.272	-5.252	4.954	F(1, 57)	CHI-SQ (2)	F(1,61)
R^2: 0.33	(-5.08)***		(2.39)**		(2.16)**	(-3.14)***	(2.86)***	6.20	27.5	3.51

[a] Logarithms of variables. [b] Ramsey's RESET test. [c] Based on a test of skewness and kurtosis of residuals. [d] Based on the regression of squared residuals on squared fitted values.
[e] OLS estimation based on Adjusted White's Heteroskedasticity-Consistent S.E.
*** 1% level of significance, ** 5% and * 10%.

TABLE 6 - *Industry Specific Determinants of UK Down-market Vertical Intra-industry Trade. 1990*

Dependent variable: VIIT-[a]	OLS				Observations 63			Diagnostics:		
Regressors[a]	Constant	SUBSE	SKUN	SCA	COMP	KL	INNOV	Function form[b]	Normality[c]	Heteroskedasticity[d]
ACs trade [e]										
	-13.838	0.806	1.793	0.015	0.058	-2.886	1.68	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.33	(-2.39)**	(2.04)**	(1.32)	(0.04)	(0.28)	(-1.21)	(0.68)	11.87	7.08	29.67
	-11.961	0.804				-0.985		F(1, 58)	CHI-SQ (2)	F(1,61)
R^2: 0.14	(-4.52)***	(2.44)***				(-2.46)***		12.46	10.87	18.38
LACs trade [e]										
	-21.440	0.544	3.798	0.706	0.376	-5.691	4.553	F(1, 55)	CHI-SQ (2)	F(1,61)
R^2: 0.28	(-4.07)***	(1.64)	(2.94)***	(1.80)*	(1.81)*	(-2.88)***	(2.26)**	1.59	0.44	8.26
	-21.77		3.739	0.867	0.562	-6.082	5.085	F(1, 56)	CHI-SQ (2)	F(1,61)
R^2: 0.23	(-3.69)***		(2.11)**	(2.04)**	(2.59)***	(-2.28)**	(1.85)*	0.30	3.38	2.98

[a] Logarithms of variables. [b] Ramsey's RESET test. [c] Based on a test of skewness and kurtosis of residuals. [d] Based on the regression of squared residuals on squared fitted values.
[e] OLS estimation based on Adjusted White's Heteroskedasticity-Consistent S.E.s (in *LACs trade*, only in the first equation).
*** 1% level of significance, ** 5% and * 10%.

SKUN reveals to be significant but not for all version of VIIT. In the case of UK-ACs trade, it has a positive impact only on $VIIT^{+}$. Again, this outcome suggests that separate testing of the upwards and the downwards components of VIIT is worth pursuing because it yields a more accurate interpretation of the sign on the skill-intensity variable, so that the direction of comparative advantage with regard to the quality of goods can be inferred.

INNOV turns to be significant for all version of VIIT, but not for all geographical groupings: it has a positive impact only on UK vertical industry trade with LACs.

4.5 Interpretation of Results

The picture emerging from our estimates for the components of UK intra-industry trade appears quite fragmented and calls for a general interpretation of results.

With respect to the recent methodology suggested by Greenaway *et al*. (1994 and 1995) for disentangling and investigating the two types of IIT, in our analysis we have introduced three innovative features: 1) computation of UVs at a deeper level of product disaggregation (8-digit CN level) in order to obtain more reliable indicators of quality differences; 2) division of VIIT in up-market and down-market components in order to model a more precise specification of the expected link between vertical intra-industry trade and the specific explanatory variables for quality differentiation; 3) division of UK trade in two geographical groupings, advanced and less advanced countries, in order to test HO explanation of VIIT appropriately.

The empirical results suggest that these innovations turn out to be useful for a more accurate description of vertical intra-industry trade, but with the by-product of a less satisfactory analysis of horizontal intra-industry trade. As my estimates have shown, HIIT is poorly explained by the theories we have considered. This lack of results for HIIT could be linked to the treatment of data and, relating to this, the criterion adopted for separating HIIT from VIIT could play a role. But, as already shown in Greenaway *et al*. (1995), estimates are unaffected by the change of the criterion assumed for defining HIIT-VIIT[7].

[7] This result is confirmed by Celi (2004) who tests the sensitivity of estimates to the dispersion criterion adopted to disentangle HIIT and VIIT. By

While the value of the criterion for dividing the two forms of intra-industry trade does not seem to be relevant, it is still in the treatment of data that the reason for the poor performance of HIIT should be looked for. We have already observed that our unsatisfactory results for HIIT could be explained by the level of disaggregation of data. The disaggregation to the 8-digit product level hides horizontal differentiation in which the attribute variety exists in inter-product trade but not in intra-product trade. So the disaggregation at the product level here adopted could explain the lack of results for HIIT.

Conversely, the 8-digit level of disaggregation is appropriate in the definition of VIIT: only in intra-product trade we expect that unit value differences genuinely reflect quality differences. In fact the estimates which we have carried out for VIIT turn out to be more robust than HIIT results.

Regression results for VIIT show that industries with more skill intensity, more investments, with more firms and with less capital intensity have more VIIT. The large numbers model of VIIT seems to be confirmed here, although the variable for economies of scale is not significant in all regressions and does not display a stable sign. The inverse relationship between VIIT and attribute differentiation expected by GHM is not confirmed here. However, in our estimates, the factor intensity variables seem to work much better than product differentiation, being significant in almost all regressions and at a higher level.

In GHM's estimates for VIIT, the specific regressor for vertical differentiation they consider (skill-intensity) is as significant as the product differentiation variable and both turn out to be alternative explanatory factors for VIIT. But, in our estimates, the skill-intensity variable is significant but not for all version of VIIT. This result suggests that it is worth to separate $VIIT^{+}$ from $VIIT^{-}$, also because this separation makes clearer the geographical differentiation of UK vertical intra-industry trade (the different pattern of ACs trade versus LACs trade, as shown).

However, the link between factor-intensity variables and $VIIT^{+}$ and $VIIT^{-}$ respectively does not emerge in the way we expected. For both components of vertical intra-industry trade, the capital-intensity

---

moving from a more strict (10%) to a more generous (30%) definition of HIIT – that is from a more generous to a more strict definition of VIIT – OLS estimates remain substantially unchanged: no large deviation in the level of significance of variables.

variable shows a negative coefficient, whereas it should be positive for up-market trade. As we have already discussed, this result is explained by the characteristics of the most capital-intensive sectors (industries producing standardized industrial goods with less scope for product differentiation).

Also results concerning the skill-intensity variable are not completely in line with a Heckscher-Ohlin view of VIIT. As shown, this variable is significant with positive sign in estimates for UK-LACs down-market VIIT; in other words, regression results suggest that the most skill-intensive sectors are those in which the UK sells more low quality goods to LACs in exchange for high quality goods. What is the explanation for this outcome?

The presence of vertical disintegration in UK trade flows could help to interpret this result. In other words, in skill-intensive sectors the UK could export to less advanced countries products to be processed and then reimported. This circumstance could imply that UVs of UK exports are lower than UVs of UK imports ($UVX^{UK}<UVM^{UK}$) not because the quality of UK goods is low but just because commodities imported are more processed than commodities exported.

5. Conclusions

This paper has offered empirical evidence concerning the industry-specific determinants of UK horizontal and vertical intra-industry trade in 1990.

The estimates illustrated in this paper have shown that horizontal intra-industry trade is inadequately explained by the models we have considered. Sensitivity analysis has produced evidence that the lack of statistical results for HIIT is not ascribable to the criterion for separating horizontal from vertical components of intra-industry trade. We have argued that the level of disaggregation adopted here could be a possible reason for that. In the agenda for future research, a comparison of estimates for HIIT conducted at different levels of disaggregation could be useful to evaluate the sensitivity of results to this explanatory factor.

The more robust estimates we have obtained for VIIT suggest that the disaggregation of trade data at the product level (8-digit) is the correct way to test the industry-specific determinants of vertical intra-industry trade. Of course, it is inherently difficult to predict VIIT using cross-sectoral data, because VIIT is an intra-sectoral

phenomenon arising from variance in quality within sectors, so we have to try to infer from the regression results the characteristics of sectors which have high quality variance.

The different patterns of VIIT between ACs and LACs trade are consistent with a Heckscher-Ohlin view of VIIT, and the statistical results make it clear that it is desirable to separate out the two forms of VIIT. However, we have not succeeded in relating the cross-sectoral distribution of the two forms of VIIT consistently to factor-intensity variables. The robust role of capital intensity in the regressions seems to indicate that the more capital intensive sectors simply have less vertical product variety and therefore less vertical intra-product trade.

We have followed GHM in using skill-intensity in the VIIT regressions in place of the horizontal product differentiation variable and in effect the first variable performs better in the explanation of the inter-sectoral distribution of VIIT. When VIIT is separately tested in up-market and down-market components, the skill-intensity variable is significant but not for all version of VIIT. This result signals that it is worth to separate the two components of VIIT, but the direction of the link between this variable and vertical intra-industry trade doesn't emerge unambiguously.

In effect, results indicate that the cross-sectoral role of factor-intensity in the explanation of VIIT does not completely derive from an HO explanation. Even our innovation of dividing VIIT in up-market and down-market components, in order to improve the specification of the link between vertical intra-industry trade and factor proportion variables, has not worked as we expected.

We have suggested a possible reason for that: a relevant presence in trade flows of vertical disintegration of production.

In the agenda for future research, it would be desirable to improve the interpretation and the robustness of not conclusive results here presented by testing the components of IIT on the basis of trade data in which final goods are separated from intermediate goods (on this regard, statistics on OPT could be employed). In addition, estimates with a better geographical disaggregation would be desirable also. With respect to this aspect, a panel data analysis able to integrate cross-sector and cross-country dimensions of UK VIIT would be optimal to evaluate the role of country-specific effects properly.

Giuseppe Celi
Università degli Studi di Foggia, Dipartimento di Scienze Economiche, Matematiche e Statistiche, Foggia, Italy

REFERENCES

Abd-el-Rahman, K.S. (1991), "Firms' Competitive and National Comparative Advantages as Joint Determinants of Trade Composition", *Weltwirtschaftsliches Archiv*, 127(1) 83-97.

Balassa, B. (1967), Trade Liberalization among Industrial Countries. Objectives and alternatives, McGraw-Hill: New York.

Balassa, B. and L. Bauwens, (1987), "Intra-industry Specialisation in a Multi-country and Multi-industry Framework", *The Economic Journal*, 97(388), 923-939.

Celi, G. (2004), "Quality Differentiation, Vertical Disintegration and The Labour Market Effects of Intra-industry Trade", CELPE Discussion Paper 86, Università di Salerno.

Celi, G. and A. Smith (1999), "Quality Differentiation and the Labour Market Effects of International Trade", University of Sussex. Mimeo.

Dixit, A.K and J.E. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity", *American Economic Review*, 67(3), 297-308.

Falvey, R.E. (1981), "Commercial Policy and Intra-industry Trade", *Journal of International Economics*, 11(4), 459-511.

Falvey, R.E. and H. Kierzkowski (1987), *Product Quality, Intra-industry Trade and (Im)perfect Competition*, in: H. Kierzkowski (Ed.), "Protection and Competition in International Trade: Essays in Honour of W.M. Corden", Blackwell: Oxford.

Greenaway, D., R. Hine and C. Milner (1994), "Country-specific Factors and the Pattern of Horizontal and Vertical Intra-industry Trade", *Weltwirtschaftliches Archiv*, 130(1), 77-100.

Greenaway, D., R. Hine and C. Milner (1995), "Vertical and Horizontal Intra-industry Trade: A cross Industry Analysis for the United Kingdom", *The Economic Journal*, 105(433), 1505-1518.

Greenaway, D. and C. Milner (1986), The Economics of Intra-industry Trade, Basil Blackwell: Oxford.

Greenaway, D., C. Milner and R. Elliott (1996), "UK Intra-industry Trade with EU North and South: A Multi-country and Multi-industry Analysis", CREDIT Research Paper No. 96/9, University of Nottingham.

Greenaway, D. and J. Torstensson (1997), "Economic Geography, Comparative Advantage and Trade within Industries: Evidence from the OECD", CEPR Discussion Paper No. 1857.

Grubel, H. and P. Lloyd (1975), Intra-industry Trade: The Theory and Measurement of International Trade in Differentiated Products, MacMillan: London.

Krugman, P. (1979), "Increasing Returns, Monopolistic Competition and International Trade", *Journal of International Economics*, 9(4), 469-79.

Krugman, P. (1981), "Intra-industry Specialization and the Gains from Trade", *Journal of Political Economy*, 89(5), 959-973.

Lancaster, K. (1980), "Intra-industry Trade under Perfect Monopolistic Competition", *Journal of International Economics*, 10(2), 151-175.

Leamer, E.E. (1984), Source of International Comparative Advantage: Theory and Evidence, MIT Press: Cambridge, MA.

Linder, S.B. (1961), An Essay on Trade and Transformation, John Wiley & Sons: New York.

Shaked, A. and J. Sutton (1984), *Natural Oligopolies and International Trade*, in: H. Kierzkowski (Ed.), "Monopolistic Competition and International Trade", Oxford University Press: Oxford.

Torstensson, J. (1991), "Quality Differentiation and Factor Proportions in International Trade: An Empirical Test of the Swedish Case", *Weltwirtschaftliches Archiv*, 127(1), 183-194.

ABSTRACT

Recent developments in the literature on intra-industry trade (IIT) have remarked the importance of disentangling horizontal and vertical components in IIT. For example, Greenaway, Hine and Milner (GHM) have investigated the determinants of IIT in the UK and have shown that the approach which distinguishes vertical from horizontal IIT is worth pursuing in order to arrive at a more accurate interpretation of empirical evidence. This paper builds on GHM's methodology whilst at the same time introducing some innovative features. The most significant is that the share of vertical differentiation in IIT is further divided into two components which are separately tested in the case of the UK: the part of vertical IIT composed of flows in which the quality of exports is higher than the quality of imports; the remaining part formed by flows in which exports appear to be downgraded in comparison with imports. This further distinction yields a more consistent specification of the expected relationship between the proxy variable for quality differentiation and vertical intra-industry trade.

Keywords: Intra-industry Trade, North-South Trade, Vertical Product Differentiation, UK Trade

JEL Classification: F13, F14

RIASSUNTO

Spiegazioni empiriche del commercio intra-industriale verticale ed orizzontale del Regno Unito: un commento

Recenti sviluppi della letteratura sul commercio intra-industriale (CII) hanno evidenziato l'importanza di separare la componente verticale da quella orizzontale nei flussi di CII. Ad esempio, Greenaway, Hine e Milner (GHM) hanno studiato le determinanti del CII del Regno Unito e hanno dimostrato che l'analisi separata delle due componenti (verticale ed orizzontale) porta ad una più accurata interpretazione dell'evidenza empirica. Questo lavoro sviluppa ulteriormente la metodologia proposta da GHM, introducendo alcuni elementi innovativi. Il più significativo consiste nell'ulteriore suddivisione della quota di commercio verticale in due componenti che sono separatamente analizzate nel caso del Regno Unito: la parte costituita da quei flussi commerciali in cui la qualità delle esportazioni è superiore a quella delle importazioni e la parte rimanente in cui si registra il contrario. Questa ulteriore distinzione genera una specificazione econometrica più coerente della relazione attesa tra la variabile indipendente che approssima la differenziazione qualitativa e il commercio intra-industriale verticale.

APPENDIX

TABLE 1A - *Sectors Included in the Sample*

NACE Code	Description
2601	Chemical and man-made fibres (25+26)
3110	Foundries
3120	Forging; drop forging, closed dieforging, pressing and stamping
3130	Secondary transformation, treatment and coating of metals
3150	Boilermaking, manufacture of reservoirs, tanks and other sheet-metal containers
3160	Manufature of tools and finished metal goods, except electrical equipment
3210	Manufacture of agricolture machinery and tractors
3220	Manufacture of machine-tools for working metal, and of other tools and equipment for use with machines
3230	Manufacture of textile machinery and accessories; manufacture of sewing machines
3240	Manufacture of machinery for the food, chemical and related industries
3250	Manufacture of plant for mines, the iron and steel industries and foundries, civil engineering and the building trade; manufacture of mechanical handling equipment
3260	Manufacture of transmission equipment for motive power
3270	Manufacture of other machinery and equipment for use in specific branches of industries
3280	Manufacture of other machinery and equipment
3440	Manufacture of telecommunications equipment, electrical and electronic measuring and recording equipment, and electro-medical equipment
3450	Manufacture of radio and television receiving sets, sound reproducing and recording equipment and of electronic equipment and apparatus (except electronic computers); manufacture of gramophone records and prerecorded magnetic tapes
3460	Manufacture of domestic type electric appliances
3470	Manufacture of electric lamps and other electric lighting equipment
3510	Manufacture and assembly of motor vehicles (including road tractors) and manufacture of motor vehicle engines
3610	Shipbuilding
3630	Manufacture of cycles, motor-cycles and parts and accessories thereof
3640	Aerospace equipment manufacturing and repairing
3710	Manufacture of measuring, checking and precision instruments and apparatus
3720	Manufacture of medical and surgical equipment and orthopaedic appliances (except orthopaedic footwear)
3730	Manufacture of optical instruments and photographic equipment
4110	Manufactures of vegetables and animal oils and fats
4120	Slaughtering, preparing and preserving of meat (except the butcher's trade)
4130	Manufacture of dairy products
4140	Processing and preserving of fruit and vegetables
4150	Processing and preserving of fish and other sea foods fit for human consumption

Continued Table 1a

NACE Code	Description
4160	Grain milling
4190	Bread and flour confectionery
4200	Sugar manufacturing and refining
4210	Manufature of cocoa, chocolate and sugar confectionery
4220	Manufacture of animal and poultry foods (including fish meal and flour)
4230	Manufacture of other food products
4240	Distilling of ethyl alcohol from fermented materials; spirit distilling and compounding
4250	Manufactures of wine of fresh grapes and of beverage base thereon
4270	Brewing and malting
4280	Manufactures of soft drinks, including the bottling of natural spa waters
4290	Man ufacture of tobacco products
4360	Knitting industry
4380	Manufacture of carpets, lineolum and other floor coverings, including leathercloth and similar supported synthetic sheeting
4410	Tanning and dressing of leather
4420	Manufacture of products from leather and leather substitutes
4510	Manufacture of mass-produced footwear (excluding footwear made completely of wood or of rubber)
4530	Manufacture of ready-made clothing and accessories
4550	Manufacture of household textiles and other made-up textile goods (outside weaving-mills)
4610	Sawing and processing of wood
4620	Manufacture of semi-finished wood products
4630	Manufacture of carpentry and joinery components and of parquet flooring
4640	Manufacture of wooden containers
4650	Other wood manufactures (except furniture)
4660	Manufacture of articles of cork and articles of straw and other plainting materials (including basketware and wickerwork); manufacture of brushes and brooms
4670	Manufacture of wooden furniture
4710	Manufacture of pulp, paper and board
4720	Processing of paper and board
4730	Printing ad allied industries
4810	Manufacture of rubber products
4830	Processing of plastics
4910	Manufacture of articles of jewellery and gold-smith's and silversmith's wares; cutting or otherwise working of precious and semiprecious stones
4930	Photographic and cinematographic laboratories
4950	Miscellaneous manufacturing industries

Industry data

Industry data is taken from European Commission's INDE database which provides information concerning 80 industrial variables for 12 EU reporting countries (France, Belgium, Luxembourg., Netherlands, FR Germany, Italy, Utd. Kingdom, Ireland, Denmark, Greece, Portugal, Spain). These variables - *inter alia* - include: number of enterprises, number of manual and non-manual workers, gross wages and salaries, social charges, labour costs, turnover, investments, purchases of intermediate products, gross added value, indirect taxes, bank charges, etc. Industries are coded and described in accordance with NACE. In the present work, I have considered the 63 3-digit NACE sectors reported in Table 1A (some sectors were excluded because of missing data). The description of the industrial variables considered in the analysis is reported in the text (section 4.1).

Trade data

Trade data on the CD-ROM is taken from the EUROSTAT COMEXT database. For 1990 *reporting countries* are the 12 EU countries already mentioned (where Belgium and Luxembourg together are treated as one). Reporting countries are identified by a geonomenclature code in combination with a validity period. A separate identifier EUR12 is available to refer to the European Communities as a whole.

Partner countries can be within or outside the EU. They are identified by a geonomenclature code in combination with a validity period. This is because the definition of countries may be subject to geopolitical change (the COMEXT database deals, for example, with a country Yugoslavia 65-91 as well as a country Yugoslavia 92-92). Separate identifiers are available to refer to groups of countries, such as the European Union as a whole, the world, and many geopolitical groupings of countries.

Products are coded and described in accordance with the Combined Nomenclature. This nomenclature has 4 hierarchical levels: HS2, HS4, HS6 and CN8. Trade data is available at every level of the nomenclature. In addition to the Combined Nomenclature, the following product nomenclatures may be available: SITC rev.3, Nace-CLIO D, Nimexe, SITC rev.2. The SITC is the standard classification system used by the United Nations Organisation. Revision 2 was in use from 1977 up to and including 1987, revision 3 was adopted in 1988. It is a hierarchical coding system with codes

consisting of 1 to 5 digits. The Nace-CLIO D is a non-hierarchical classification used for the European System of Integrated Economic Accounts. It was adopted in 1976, and codes consist of 3 digits. The Nimexe nomenclature was used up to 1 January 1988 and is closely correlated to the Combined Nomenclature. It is a hierarchical system, with product codes consisting of 2, 4, or 6 digits.

Concordances are available to correlate the SITC rev. 3 and the Nace-CLIO D to the Combined Nomenclature, the SITC rev. 2 and the Nace-CLIO D to the Nimexe nomenclature, and the Nace-CLIO D to the SITC.

In this work, we focussed on concordance between CN8 classification and the NACE industrial classification. In other words, data permits to know all 8-digit commodities included in each NACE sector. So it is possible to calculate IIT indices disaggregated at the 8-digit level for each 3-digit NACE sector and to regress them on industrial variables which are identified at the 3-digit NACE level. The total number of commodities included in the 63 sectors considered in the sample is 5401.

Table 2A shows an example of how HIIT, VIIT, $VIIT^+$, $VIIT^-$ indices are calculated in the case of NACE sector 364 (aerospace equipment manufacturing and repairing). In the first column, the code of the 57 8-digit commodities included in NACE sector 364 are reported. The following 4 columns display trade flows (value and volume of imports, exports). Columns 6 and 7 report unit values for imports and exports (obtained as values/volumes ratio). Columns 8 and 9 select flows vertically differentiated, that is trade in which $\frac{UV_i^x}{UV_i^m} \leq 1-\alpha$ or $\frac{UV_i^x}{UV_i^m} \geq 1+\alpha$, where α =0.2. Columns 10 and 11 select up-market flows only, that is trade of those commodities for which $\frac{UV_i^x}{UV_i^m} \geq 1+\alpha$. GL index for total IIT is calculated on flows reported in columns 2 an 3. GL index for VIIT is computed on flows reported in columns 8 and 9. $VIIT^+$ is measured on flows reported in columns 10 and 11. GL indices for HIIT and $VIIT^-$ are calculated as residual.

TABLE 2A - *Example of Grubel-Lloyd Indices Calculation from Spread Sheet – NACE 364*

criterion 0.2 products 57

Period : 90-52 JAN - DEC Reporting countries : 006 73-94 UTD. KINGDOM

Partner countries : 1000 58-94 W O R L D

Units : 1000 ECU, Metric Tons

Grubel-Lloyd indices	
G-L	0.59382
G-L V	0.52252
G-L H	0.07130
G-L V+	0.29114
G-L V-	0.23138

Products	Flows				Unit values		Vertical flows		Vertical flows +	
	IMP value	EXP value	IMP vol	EXP vol	IMP UV	EXP UV	IMP	EXP	IMP	EXP
364 ND 88-94	7360171	9504081	7256	8895						
84071010 88-94	3610	2935	48	96	75.2	30.6	3610	2935	0	0
84071090 88-94	3341	3969	74	156	45.1	25.4	3341	3969	0	0
84089010 88-94	291	932	8	64	36.4	14.6	291	932	0	0
84091010 88-94	16711	35005	76	219	219.9	159.8	16711	35005	0	0
84091090 88-94	10358	26583	324	643	32.0	41.3	10358	26583	10358	26583
84111110 88-94	72063	25027	97	80	742.9	312.8	72063	25027	0	0
84111190 88-94	26019	45004	140	111	185.9	405.4	26019	45004	26019	45004
84111211 88-94	100831	14257	119	21	847.3	678.9	0	0	0	0
84111213 88-94	104436	508008	241	878	433.3	578.6	104436	508008	104436	508008
84111219 88-94	302842	1369231	788	2375	384.3	576.5	302842	1369231	302842	1369231
84111290 88-94	247683	64832	696	163	355.9	397.7	0	0	0	0
84112110 88-94	15461	50065	33	106	468.5	472.3	0	0	0	0
84112190 88-94	16028	16099	86	30	186.4	536.6	16028	16099	16028	16099
84112211 88-94	47457	18107	57	54	832.6	335.3	47457	18107	0	0
84112219 88-94	657	1713	4	10	164.3	171.3	0	0	0	0
84112290 88-94	41331	10421	143	45	289.0	231.6	0	0	0	0
84118110 88-94	68146	29679	164	71	415.5	418.0	0	0	0	0
84118190 88-94	71875	88739	284	385	253.1	230.5	0	0	0	0
84118210 88-94	10826	12827	93	108	116.4	118.8	0	0	0	0
84118291 88-94	52963	87676	188	1171	281.7	74.9	52963	87676	0	0
84119190 88-94	562020	342122	1984	1410	283.3	242.6	0	0	0	0
84121010 88-94	754	2963	17	40	44.4	74.1	754	2963	754	2963
84121090 88-94	1468	5980	34	110	43.2	54.4	1468	5980	1468	5980
84123110 88-94	2051	108	4	5	512.8	21.6	2051	108	0	0
84123910 88-94	1174	498	11	7	106.7	71.1	1174	498	0	0
84128091 88-94	4991	228	44	3	113.4	76.0	4991	228	0	0
84129030 88-94	2369	4495	33	83	71.8	54.2	2369	4495	0	0
84798910 88-94	16655	3526	511	86	32.6	41.0	16655	3526	16655	3526
84799010 88-94	14673	4785	955	365	15.4	13.1	0	0	0	0

Continued Table 2a

criterion 0.2 products 57

Period : 90-52 JAN - DEC Reporting countries : 006 73-94 UTD. KINGDOM

Partner countries : 1000 58-94 W O R L D

Units : 1000 ECU, Metric Tons

Grubel-Lloyd indices	
G-L	0.59382
G-L V	0.52252
G-L H	0.07130
G-L V+	0.29114
G-L V-	0.23138

Products	Flows				Unit values		Vertical flows		Vertical flows +	
	IMP value	EXP value	IMP vol	EXP vol	IMP UV	EXP UV	IMP	EXP	IMP	EXP
88011010 88-94	1215	576	1	1	1215	576	1215	576	0	0
88011090 88-94	1482	1537	1	1	1482	1537	0	0	0	0
88019010 88-94	1022	2905	1	1	1022	2905	1022	2905	1022	2905
88019091 88-94	996	6323	1	1	996	6323	996	6323	996	6323
88019099 88-94	55	399	1	1	55	399	55	399	55	399
88021110 88-94	19154	9080	1	1	19154	9080	19154	9080	0	0
88021190 88-94	208	514	1	1	208	514	208	514	208	514
88021210 88-94	47415	15456	1	1	47415	15456	47415	15456	0	0
88021290 88-94	1	115457	1	1	1	115457	1	115457	1	115457
88022010 88-94	17167	18470	1	1	17167	18470	0	0	0	0
88022090 88-94	2064	1579	1	1	2064	1579	2064	1579	0	0
88023010 88-94	153713	513346	1	1	153713	513346	153713	513346	153713	513346
88023090 88-94	10555	592956	1	1	10555	592956	10555	592956	10555	592956
88024010 88-94	3216032	1763620	1	1	3216032	1763620	3216032	1763620	0	0
88024090 88-94	120194	1	1	1	120194	1	120194	1	0	0
88031010 88-94	16475	43354	1	1	16475	43354	16475	43354	16475	43354
88031090 88-94	109234	38122	1	1	109234	38122	109234	38122	0	0
88032010 88-94	31501	113653	1	1	31501	113653	31501	113653	31501	113653
88032090 88-94	17621	18935	1	1	17621	18935	0	0	0	0
88033010 88-94	518314	864786	1	1	518314	864786	518314	864786	518314	864786
88033090 88-94	516108	1125711	1	1	516108	1125711	516108	1125711	516108	1125711
88039010 88-94	127	354	1	1	127	354	127	354	127	354
88039091 88-94	6697	23679	1	1	6697	23679	6697	23679	6697	23679
88039099 88-94	648677	1269617	1	1	648677	1269617	648677	1269617	648677	1269617
88051010 88-94	871	3814	1	1	871	3814.00	871	3814	871	3814
88052010 88-94	58920	149117	1	1	58920	149117	58920	149117	58920	149117
88052090 88-94	25270	34907	1	1	25270	34907	25270	34907	25270	34907
88990000 93-94	1	1	1	1	1	1	0	0	0	0

TABLE 3A - *Descriptive Statistics for Sample*

Variable	Mean value	Standard deviation	Minimum value	Maximum value
SUBSE	85.73	83.62	4.00	365.00
SCA	36.27	108.22	2.37	821.49
COMP	394.41	504.85	6.00	2537.00
SKUN	0.051	0.031	0.018	0.169
KL	0.0045	0.0032	0.0009	0.0146
INNOV	0.1330	0.0540	0.0380	0.2740
UK-ACs trade				
IIT	0.498	0.196	0.024	0.852
HIIT	0.212	0.137	0.00013	0.605
VIIT	0.286	0.159	0.002	0.673
$VIIT^{+}$	0.177	0.131	0.002	0.647
$VIIT^{-}$	0.109	0.098	0.0001	0.443
UK-LACs trade				
IIT	0.228	0.017	0.004	0.844
HIIT	0.043	0.108	0.0001	0.844
VIIT	0.186	0.145	0.0001	0.662
$VIIT^{+}$	0.157	0.138	0.0001	0.662
$VIIT^{-}$	0.029	0.043	0.000001	0.1996