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Economic Geography, Comparative Advantage and Trade Within Industries: Evidence from the OECD*

David Greenaway, CREDIT, University of Nottingham and Johan Torstensson, Lund University, The Trade Union Institute for Economic Research (FIEF, Stockholm), CEPR and CREDIT, University of Nottingham

Addresses:
David Greenaway
CREDIT, University of Nottingham, University Park
Nottingham NG7 2RD
U.K
Fax +44 115 9515552
E-mail: David.Greenaway@nottingham.ac.uk

Johan Torstensson
Department of Economics, University of Lund
P.O. Box 7082, S-220 07 LUND
Sweden
Tel +46 46 2224972
Fax +46 46 2224613
E-mail: Johan.Torstensson@nek.lu.se

Abstract:
A large share of world trade, especially among the OECD countries, is two-way trade within industries, so called intra-industry trade. Despite this, few attempts have been made to examine why countries export some products within industries, whereas they import others. We examine this issue, by means of regression analysis, by examining the shares of IIT that are vertical and horizontal and by examining price dispersion. The regression results suggest that an abundant human capital endowment as well as a large domestic market increases the quality of OECD-countries' manufacturing exports, thus offering support for comparative advantage models as well as newer geography models. We do not, however, find support of increased concentration of production within industries. But, human capital becomes an increasingly important determinant of quality over time.

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I. INTRODUCTION

It is difficult to overstate the importance of analysing the underlying causes of industrial specialisation and international trade. Without a knowledge of the causes of trade and specialisation, one cannot predict its effects, nor are analyses of trade and industrial policies especially fruitful. A large number of studies have examined determinants of net trade and industrial specialisation.[1] However, these have dealt exclusively with trade *between* industries, ignoring determinants of trade *within* industries despite the fact that a large share of world trade consists of so called intra-industry trade (IIT).[2] The first part of this study, therefore, examines, for the OECD-countries, determinants of trade within industries.[3]

The second part examines changes in industrial location within industries as trade costs are reduced. Is production of particular varieties becoming more or less concentrated? Empirically documented changes towards more concentrated production at the industry level are still on a modest scale. However, studying changes in location at the industry level may seriously underestimate total structural changes, if there are also important intra-industry changes. It is, for example, possible that the adjustment consequences of horizontal intra-industry trade (HIIT) differ from those of vertical intra-industry trade (VIIT) with the social costs of the latter being higher and more in line with those of inter-industry changes[4].

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1 Most of these empirical studies have taken their starting point in the Heckscher-Ohlin model where net trade is determined by factor proportions. The empirical evidence on this issue is somewhat mixed. However, during the last few years, some studies have offered stronger empirical support for the H-O model, especially if complemented by the other main explanation of comparative advantage: technical differences. See Trefler, 1995, Davis and Weinstein (1996), Davis et. al. (1996), Harrigan (1996). For a recent review of the evidence see Leamer & Levinsohn 1995.

2 On reasonable levels of aggregation, it is possible that at least half of world trade consists of IIT (see Greenaway and Milner, 1986), and this share is even higher in trade between OECD-countries.

3 This part of the study is therefore in its approach more similar to earlier studies of inter-industry specialisation and trade, than to earlier studies of IIT, since they have typically asked why the share of IIT is particularly high in some industries, for some countries or in some bilateral trade flows.

4 Only one study has examined this issue: that of Fontagne, Freudenberg and Pèridy (1997), (later used by the European Commission, 1997) which examines trade specialisation between 1980-1994. Although they find some evidence that at the industry level, there is a slight convergence of manufacturing structures, their results also suggest that, within

The remainder of the paper is organised as follows. Section II sets the scene by reviewing some general considerations relating to specialisation trade and structural change. In Section III we then set out alternative theoretical models of trade within industries which informs the empirical framework of Section IV. The results of estimating our empirical model are discussed in Section V. Finally, Section VI concludes.

2. SPECIALISATION, TRADE AND STRUCTURAL CHANGE WITHIN INDUSTRIES: SOME GENERAL CONSIDERATIONS

Theoretically, the most widely used framework for explaining IIT is monopolistically competitive models where trade is driven by scale economies and horizontal product differentiation. In the simplest version, with no trade costs, trade within industries is indeterminate so country specialisation cannot be predicted. But, this version does not perform well empirically.[5] This question mark on the conventional causes is further strengthened by the evidence provided by Greenaway, Hine and Milner (1994, 1995) who suggest that it does not seem to be horizontal but rather vertical IIT that is in practice dominant.

We therefore want to deal with the determinants of IIT in the same manner as we would analyse net trade specialisation. Is that possible? Not if the assumptions of the monopolistic competition model were exactly true empirically. Then, all products would have identical factor-intensities, scale economies would be equally important in the production of all products and which country specialised in the production of

industries, there is some tendency towards increased concentration along the lines of vertical IIT and of increased price dispersion.

[5] A first generation of empirical tests of IIT seemed to offer some confirmations of the monopolistic competition and horizontal differentiation explanation of IIT (see Greenaway and Milner, 1987, for a survey of industry and country studies and Helpman, 1987, for an influential study of the country pattern of IIT). In recent years, however, quite damaging evidence to the monopolistic competition explanation of horizontal IIT has been offered. In particular, the results in Torstensson (1996) suggest that industry determinants of IIT are very sensitive to various econometric problems. Moreover, the results in Hummels and Levinsohn (1995) cast some doubt on the usefulness of monopolistic competition as explaining the country pattern of IIT.

which specific differentiated products would be completely arbitrary. On the other hand, if products within an industry differ in some more fundamental respect, an analysis of determinants of trade within industries is feasible. Differences may originate in the demand or supply side. We concentrate on supply and assume that products within an industry differ either in factor-intensities[6] or in the degree to which scale economies are important.[7] Such differences could in principle be measured directly if we had access to industrial data at a sufficiently disaggregated level. Unfortunately, we do not. So we have to identify other characteristics that can be assumed to be related to supply characteristics. One prime candidate is quality.

Falvey (1981) and Falvey and Kierzkowski (1987) assumed that the capital-intensity required in production is increasing in quality of vertically differentiated products. Greenaway and Milner (1986) argued that human capital is important in production of high-quality varieties. So, we assume that equilibrium capital-intensities are increasing in quality of vertically differentiated products. We also assume that scale economies increase with quality for which there are two justifications: first, fixed costs for product development seem to be more important for high- than for low-quality varieties and, second, different high-quality varieties are likely to be less close substitutes for each other than are different low-quality varieties. With monopolistic competition, the ratio of average to marginal costs depends, in equilibrium, only on the elasticity of substitution between different varieties of a good. So, with a low elasticity of substitution as with high-quality varieties, in equilibrium scale economies will be important.

Casual empiricism supports this assumption and the results in Greenaway, Hine and Milner (1995) offer some indirect support. They examine, separately, determinants of

[6] This is, however, certainly not to argue that IIT is a statistical artefact. By adding together products with different factor-intensities or technologies, without other reasons to constitute an ‘industry’, in the same statistical product group, IIT could be explained in a simple H-O fashion. However, the persistence of IIT at very low levels of aggregation suggest that it is a real phenomenon.

[7] We are generally not able to examine differences in technologies within industries, although this case may be important empirically. See Davis (1995) for a theoretical model where such differences give rise to IIT.

vertical and horizontal IIT and show that they do differ. In particular, while vertical IIT seems to be positively influenced by markets that are characterised by a large number of firms, horizontal IIT seems positively influenced by a low degree of scale economies and a small number of firms. Theoretical models of location and horizontal IIT suggests that we should expect a negative relationship between such IIT and scale economies. Thus, when IIT is separated between horizontal and vertical IIT, the theoretical results in Greenaway, Hine and Milner correspond to the predictions from the monopolistically competitive models.

3. THEORETICAL MODELS OF TRADE WITHIN INDUSTRIES

We can think of general considerations more formally. First, we consider a simple H-O-S framework then a simple economic geography model. Our aim is to test whether the same type of empirical explanations of trade within industries as those proposed earlier as explanations of trade between industries hold. We make no strong claims for theoretical originality: rather, we offer useful re-interpretations of well-known models in the context of trade *within* industries.

Heckscher-Ohlin and Trade within Industries: In its simplest version the H-O-S model predicts that the relatively capital-abundant country will export the capital-intensive good whereas the labour-abundant country exports the labour-intensive good. Various generalisations to higher dimensions have been made. In general the theory holds, at least as correlations so that countries will on average export those products that make an intensive use of their relatively abundant factors (see e.g. Deardorff 1982). So what use of this can be made in studying trade within industries? The answer lies in reinterpreting the general term ”product”. In brief two products may either belong to the same industry or to two different industries. Consider therefore one of the simplest generalisations of the H-O-S model: the two-factor, many country and many product version by Jones (1974) and Deardorff (1979). Initially, let us assume constant returns and a market structure of perfect competition.

This can be illustrated via the Lerner-diagram, set out as figure 1. For simplicity, we consider only one industry.[8] There are 5 qualities. The unit-value isoquants for the products show combinations of capital and labour that can produce one unit of output. There are three countries. The unit-isocost lines w_j define combinations of capital and labour that cost one unit in country *j*. Because price in equilibrium equals average cost, the unit-value isoquant must be tangential to the isocost lines when a product is actually produced by country *j*. The rays from the origin, k_j, illustrate the capital-labour ratios of the three countries. The figure shows that the most capital abundant country A produces the two products with highest qualities, 1 and 2. Country B has an intermediate capital-labour ratio and produces products 2, 3 and 4. The most labour-abundant country C produces the two products with the lowest quality, 4 and 5. This suggests a positive relationship between the capital-labour ratio of countries and the quality of vertically differentiated products in their exports.

Economic Geography and Trade Within Industries*:* An alternative hypothesis is to suppose that trade within industries is determined by scale economies and market access. Consider a reinterpretation of the Helpman-Krugman (1985, chapter 10) model. Assume that all factors are industry-specific but there is only one factor specific to each industry, labour. There are two countries, A and B, that have access to identical technologies and two qualities within each industry. The low quality variety is produced under constant returns to scale and perfect competition. This captures the assumptions that fixed costs for product development are relatively unimportant in low-quality varieties and that different low-quality varieties are close substitutes for each other. On the other hand, high-quality varieties are produced under increasing returns to scale and monopolistic competition which captures the assumption that product development is important in the production of high-quality varieties and that different high-quality varieties are imperfect substitutes for each other.

[8] The inclusion of more than one industry would not change the implications with regard to the direction of intra-industry trade.

For simplicity we assume that there are constant expenditure shares on high- and low-quality varieties, respectively. This amounts to assuming that there is a low elasticity of substitution between the two. In turn, this means that we can in effect treat the markets for low- and high-quality varieties as separate and assume perfect competition in the low-quality market and monopolistic competition in the high-quality market. Although some models predict 'small numbers' when vertical product differentiation is present (e.g. Gabszewicz, Shaked, Sutton and Thisse 1981), others have a 'large numbers' outcome (e.g. Falvey 1981).

In formal terms the sub-utility function for industry X is:

$$U_x = (\sum_{i=1}^{n} h_i^{\varepsilon})^{\gamma/\varepsilon} \quad L^{1-\gamma}, \ \ 0 < \varepsilon < 1, \ \varepsilon = 1 - (1/\sigma)$$

where h_i is the consumption of high-quality varieties in industry X and L consumption of the (only) low-quality variety. Without loss of generality, we can choose units so that GDP is one in country A and L units in country B. Finally, we assume zero trade costs prevail in production of low-quality varieties, but that there are trade costs in high-quality varieties.[9] This means that only a certain part $(1/\tau, \ \tau > 1)$ of each exported unit is received by the importer. Finally, we assume that all countries in all industries have some production of low-quality varieties. This means that wage rates throughout are equalised across countries.

The Analysis: Given our assumptions, aggregate demand for high-quality products produced in the two countries will be:

$$\begin{aligned} D_A = n_A x_A = & \left[\left[n_A p_A^{-\sigma}\gamma \ \right] / \ \left[n_A p_A^{1-\sigma} + n_B (p_B\tau)^{1-\sigma} \ \right]\right] \\ & + \left[\ \left[n_A (p_A\tau)^{-\sigma} \tau L \ \right] / \left[n_A (p_A\tau)^{1-\sigma} + n_B p_B \ \right]\right] \end{aligned} \qquad (1a)$$

$$\begin{aligned} D_B = n_B x_B = & \left[\left[n_B (p_B\tau)^{-\sigma}\gamma \ \right] / \ \left[n_A p_A^{1-\sigma} + n_B (p_B\tau)^{1-\sigma} \ \right]\right] + \\ & \left[\ \left[n_B p_B^{-\sigma} \tau L \ \right] / \left[n_A (p_A\tau)^{1-\sigma} + n_B p_B \ \right]\right] \end{aligned} \qquad (1b)$$

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[9] Davis (1997) shows that this assumption can be critical for the theoretical results we obtain. However, whether the model still works well or not is ultimately an empirical question.

where D_A and D_B are the demand for high-quality products produced in country A and B, respectively; n_A and n_B are the number of high-quality firms in country A and B, respectively; x_A and x_B are output per high-quality firm in the two countries; γ is the share of expenditure devoted to high-quality varieties. The first term in each expression therefore represents demand from country A and the second term demand from country B. Production is undertaken with increasing returns to scale. Each firm's average cost in production of high-quality varieties in country j is:

$$AC_{xj} = \eta w + (\mu w / x_j)$$

where ηw is the constant marginal cost, μw fixed cost and x_j output per firm. From the assumptions that profits are driven to zero, and firms maximise profits by setting marginal revenue equal to marginal cost, we derive equilibrium output per firms as:

$$x = (\mu\varepsilon / (\pi(1-\varepsilon))$$

Thus, output per firm will necessarily be equalised across countries. In this context, it can be shown that the equilibrium number of firms in each country equals:

$$n_A = \left[\gamma(1-\rho L)\ \right] / \left[(1-\rho)x\ \ \right] \quad (3a)$$

$$n_B = \left[\gamma(L-\rho)\ \right] / \left[(1-\rho)x\ \right] \quad (3b)$$

where we define $\tau^{1-\sigma} = \rho < 1$.

By inspection of (3a)-(3b), we can see that the larger country will always be a net exporter of high-quality varieties, whereas the small country will export the low-quality variety. This is driven by the constant expenditure shares on the two qualities; net trade is determined by whether the ratio of $n_A / (n_B L)$ is greater or smaller than one. From (3a) and (3b), this ratio is given as: $(1-\rho L)/(L(1-\rho))$. Clearly, the question of whether it is greater or smaller than unity reduces to whether $(1-L^2) \gtrless 0$. Thus, if for example country A is the larger country (L<1), it is also a net exporter of high-quality products and imports low-quality products.

It is also easy to show that the net export of high-quality varieties will be higher, the more important are scale economies and the larger the difference in country size. Furthermore, reductions in trade costs will increase net specialisation such that production of high-quality varieties will gradually become more concentrated in the large country. Trade within these industries will therefore increasingly take place in different qualities. In other words, IIT in vertically differentiated products will tend to increase whereas that in horizontally differentiated products decreases.

4. AN EMPIRICAL FRAMEWORK

Thus, we have two theoretical frameworks, one in which relative factor abundance, and another in which relative country size, determines trade within industries. We now test whether market access and relative capital endowment affects the quality of products by regressing quality in trade on measures of market access, such as the size of the home market. Then we examine whether production within industries is becoming more specialised. In addition to regression analysis, we calculate the share of total trade that is HIIT and VIIT, respectively. Finally, we calculate whether import price dispersion has increased. In doing this, we examine quality in all manufacturing products (ISIC3), based on the assumption that quality differences are important in all or most manufacturing industries. Since the data requirements are extremely demanding, we restrict ourselves to examining imports into Sweden, on the assumption that OECD-countries' exports to Sweden broadly reflect the quality of their total exports. There are no *a priori* reasons to expect that exports to Sweden are not representative of OECD countries' total exports.

Even when one restricts the analysis to OECD exports to Sweden, the data requirements remain demanding. We have to work at the 6-digit level of SNI, the Swedish ISIC-based classification where there are 169 industries. At this level of aggregation, it is plausible to assume that price differences do in fact pick up quality differences reasonably well, even in the case where consumers have imperfect information (see Stiglitz, 1987)[10]. In line with other multi-industry studies of trade

[10] With vertical differentiation, we assume that all individuals had the same ranking of products. The only reason for an individual to consume a low-quality rather than a high-quality product is that the low-quality product has a lower price. Thus, if two products are offered at the same price, all individuals will choose the product with the higher quality (Sutton (1986)). Assuming that consumers have perfect information one can conclude that if one product in an industry is sold at a higher price than another, the former must have a

we start from the position that at such disaggregated levels, relative prices do in most ways reflect relative qualities (see Torstensson, 1991, Abd-al-Rahman, 1991, Greenaway, Hine & Milner, 1994, 1995, European Commission 1996).

Let us now focus on the first hypothesis. More specifically, assume that quality in imports from country j in industry h can be expressed as:

$$z_{hj} = \beta_{1h} HCAP_j^{\beta 2} PCAP_j^{\beta 3} MARKSIZE_j^{\beta 4} \qquad (4a)$$

where HCAP is human capital endowment, PCAP is physical capital endowment, MARKSIZE is domestic market size. So, consider the following regression:

$$\ln z_{hj} = \ln \beta_{1h} + \beta_2 \ln HCAP_j + \beta_3 \ln PCAP_j + \beta_4 \ln MARKSIZE_j \qquad (4b)$$

Positive coefficients for the variables for capital endowments (PCAP, HCAP) are consistent with support for the Heckscher-Ohlin theory; a positive coefficient for MARKSIZE suggests support for geography models. Clearly if none of the coefficients were significant, this offers indirect support for the simplest monopolistic competition model with frictionless trade.

As in Leamer (1984) and others, we measure the *endowment of physical capital,* PCAP, by the depreciated sum of cumulated gross domestic investment. using calculations adjusted according to purchasing power parities (PPP) presented as capital stock per worker in the PENN World Tables, Summers and Heston (1991) database. This is a fairly straightforward and probably reasonably accurate measure of the relative endowment of physical capital. It is somewhat more difficult to construct useful measures of human capital endowment. However, Barro and Lee (1996) provide data on school attainment for persons over 15 and 25 respectively, for five-year intervals from 1960-1990. We use three measures from Barro and Lee and, since in the OECD, only a small proportion of the labour force starts working at the age of 15, we concentrate on school attainment for persons over 25. The first measure is the mean school years (HUMCAP1), the second and third are the shares of population that have completed secondary and higher education, respectively. These are denoted

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higher quality. Consequently, a ranking of products according to price should correspond to a ranking according to quality.

HUMCAP2 and HUMCAP3. Market size (MARKSIZE) is somewhat more straightforward, with total GNP expressed in PPP, taken from *Penn World Tables,* being used.

The equations were estimated for 1969, 1981 and 1994,[11] first for each of the years separately, then pooled to construct a panel where we allow both the intercept and the slope coefficients to vary across time periods. Clearly, since price levels change, we expect the intercepts to differ across time periods. The slope coefficients will differ if determinants of trade within industries change over time. The role of capital endowments as determinants could change over time, but there are no *a priori* reasons to expect this. However, theory does provide us with explicit *a priori* reasons to expect the coefficients capturing market access to change through time, since reductions in trade costs could have an effect, on the location of high-quality production. Different models offer different predictions on whether production within industries is expected to be more or less concentrated, as trade costs are reduced. Note, also that we do not attempt to explicitly link factor-intensities and scale economies to quality. In this sense, our approach is similar to that used in inter-industry production and trade studies (e.g. Leamer (1984), Davis and Weinstein (1996) and Harrigan (1996)).

In addition to regression analysis, we also ask whether horizontal or vertical IIT has increased most. We distinguish between horizontal and vertical following Greenaway, Hine and Milner (1994, 1995). This approach starts from the assumption that quality is reflected in price which can be proxied by unit values. Specifically, suppose:

$$IIT_j = 1 - \frac{\sum \left| X_{ij}^p - M_{ij}^p \right|}{\sum \left| X_{ij}^p + M_{ij}^p \right|} \qquad (5)$$

where p refers to horizontally or vertically differentiated products and i refers to fifth digit SITC products in a given third digit industry. Then

$$B_j = HB_j + VB_j \qquad (6)$$

11 Note that since the intercept is industry-specific, one dummy for each industry is included in the empirical model and the dummies are treated as fixed effects.

where HB_j is given by (5) for those products (i) in *j* where unit values of imports $\left(UV_{ij}^{m}\right)$ and exports $\left(UV_{ij}^{x}\right)$ for a given dispersion factor, satisfy the condition:

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

and VB_j is given by (5) for those products (i) in *j* where:

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

Greenaway, Hine and Milner (1994), (1995) calculate HIIT and VIIT for the UK using both α =0.15 and α =0.25. Even with the latter, which implies a large price wedge, VIIT remains very significant, indeed as important as HIIT. Using the narrower wedge of 15%, VIIT turns out to be clearly the most important form of IIT in UK trade. In this study, we use both 15% and 25% for distinguishing between HIIT and VIIT. When the narrower wedge is used, we define the variables HIIT1 and VIIT1 and with a 25 % wedge, HIIT2 and VIIT2.

Another method of examining vertical and horizontal IIT is through measuring changes in the coefficient of variation of import prices within each and every industry. If countries increasingly specialised in varieties with similar qualities, the coefficient of variation could be expected to decrease. But, if they specialised in varieties of different qualities, this would be reflected in greater price dispersion and therefore an increased coefficient of variation.

5. RESULTS

This section is divided into two parts: in the first, we study determinants of trade within industries and rely on regression analysis. Then, we examine whether production within industries is becoming more concentrated via the regressions, by computing horizontal and vertical IIT and by measuring price dispersion of imports.

Determinants of Trade Within industries: Regression Results The regression results are presented in Tables 1a and 1b. The first presents results from the individual regressions, the second from the panel regressions. Before commenting on the Tables, two remarks are in order. First, although we have estimated equation 4b using three different alternative measures for human capital, the results are presented only where HUMCAP is used, since the choice of which human capital variable to include affects neither the other variables nor the estimated effects of human capital on quality. Second, since we work with cross-section data, we make corrections for heteroscedasticity using the method introduced by White (1980).

As the tables show, both human capital endowment and total size of the home market affect the quality of exported products positively. Although significant at the 1 % level in 1969, the importance of human capital for trade within industries seems to increase over time. The coefficient for total market size is positive throughout with high *t*-statistics. But, relative endowments of physical capital do not seem to affect the results in a consistent manner. The coefficient for physical capital is sometimes positive while at other times negative. In 1981, it is even negative and significant. However, in the other years, it is mostly positive and in combination with some of the variables for human capital, sometimes positive and significant.

Table 1b presents the panel results. In the second column, we restrict the coefficients of interest to be equal in all three periods (and thus only allow for a general price change between periods). Still, the coefficients for human capital and market size are positive and significant, with higher t values. In the third column of Table 1b, we allow the country coefficients to change over time, by interacting the variables with time-dummies. It is clear that the coefficient of human capital increases from 1969 to 1981 and 1994, since the HCAP81 and HCAP94 are both statistically significant. The market size variable is, however, more or less unchanged from 1969 onwards.

It is also noteworthy that the relationship between human capital endowment and the quality of exports is robust. Although the three measures of human capital we use are quite similar, two problems remain.[12] First, it is only able to capture the quantity and not quality of education and, secondly, it does distinguish between different types of education. Even better measures of human capital would take quality into consideration and focus on the type of education. Although data that is cleansed of such factors are difficult to come by, in *OECD Education at a Glance*, data on science and engineering personnel between the ages of 25-34 as a proportion of the labour force are available for 16 of the OECD-countries and we experiment with this as HUMCAP4. Finally, the variable HUMCAP5 attempts to take quality of education into account. The *Third International Maths and Science Study* sets out to evaluate this in Maths and Science in 41 countries, out of which 18 are OECD-countries. The results of using HUMCAP4 and HUMCAP5 are interesting. Although the correlation between the two is low as is the correlation between these and the three other measures of human capital, in 1981 and 1994 they also positively and significantly affect the quality of exports. So, different aspects of training and human capital seem to be important in determining trade within industries.

Exploring Robustness Thus human capital and market size do seem to have an effect on the pattern of trade within industries. However, a number of potential limitations should be acknowledged. First the restrictive structure we have imposed on the model amounts to assuming that the effects of capital endowment and country size should be similar across manufacturing industries.[13] This was subsequently tested by using industry dummies interacting with the country characteristics. The assumption of the interaction coefficients being equal to zero could, at the 5% level, not be rejected for either year or characteristic. We take this as reassuring.

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[12] They all are quite highly correlated with each other, with the simple correlation coefficients being around 0.7.

[13] An alternative approach may therefore be to use a disaggregation of industries and estimate determinants of each industry separately. Such an approach has been used by Hansson (1993) with somewhat mixed results. Relative factor endowments are good predictors of the trade patterns in some of the industries while in the majority they are not. In particular in textiles and clothing are factor endowments good predictors.

Second, although the coefficients are mostly highly significant, it should be noted that we have a very large number of observations. The, conventional classical *t*-values may not therefore be appropriate. Leamer (1978) presents the *asymptotic Schwartz-Leamer t*-value which is equal to $\left[\ (T^{1/T}-1)(T-1)\ \right]^{0.5}$ where T is the degrees of freedom. Even if we use this stronger criterion, however, all the coefficients for human capital and market size remain significant.

Third, since the variables capturing capital endowment and market size are proxies, we want to ensure that measurement errors do not affect the results. Therefore, we use the reverse regressions test by Klepper and Leamer (1984). The results (available on request), show that the variables for human capital and market size are both bounded and therefore inferences can be drawn even assuming measurement errors.

A fourth potential econometric problem is non-normality of the error terms. OLS estimates may then be less efficient than other estimates. We therefore perform a joint test for skewness and kurtosis as suggested by Shapiro-Wilk (1965). The hypothesis of normality at the 5 % level can be rejected for all regressions. In this case, robust regressions should be preferred.[14] The results are presented in *Table 2*. The main conclusions from the OLS estimations are upheld and even somewhat strengthened. In fact, *t*-statistics are now generally higher for the market size and human capital coefficients.

Fifth, it may be that country-specific and time-independent factors do affect the results in addition to the country characteristics included in the regressions. Therefore, we take advantage of the panel and introduce country-specific fixed effects (but also experiment with random effects without this affecting the results). One obvious problem is however that the country characteristics do not vary much over time. In fact, an analysis of variance (ANOVA) shows that more than 85 percent of the

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[14] We have used the “robust regression “ employed by *STATA*. It works iteratively first by performing a regression, calculating weight based on residuals and then using these weights for further regressions until changes in weights drop to a certain level.

variation in country size is cross-sectional rather than over time. Real capital per worker varies most (almost 30 % is variation over time), whereas for the human capital measures, cross-sectional variations are dominant (over 90 %). The results (again available on request) show that both the human capital and market size variables are still positive and significant.

Finally, unit import prices are recorded c.i.f, i.e. inclusive of costs of transportation. If such costs are substantial and differ across exporters, this may affect the results. Country dummies may pick up transportation costs. These should be lower for European than for non-European exporters. Therefore, we added a European dummy that takes the value of 1 if a country is a member of EC or EFTA and 0 otherwise. The dummy should be positive if it captures costs of transportation. This dummy is useful in that it can also capture effects of European integration in the EC and EFTA. Such integration could facilitate the export of IRS- high-quality varieties. If this is the case, the dummy should instead be negative. The empirical results are presented in the last column of Table 1b. The European dummy is positive and highly significant as expected if transportation costs affected unit prices. However, the human capital and market size coefficients are still positive and highly significant. In fact, even the variable for physical capital is now positive with a significant *t*-statistic.

Is Production within Industries Becoming More Specialised? We also examined the effects of reduction of trade costs on location of production within industries based on the hypothesis that market size in certain intervals of trade cost could lead to more concentrated production within industries and less concentrated in other intervals. Moreover, reductions of trade costs could make factor proportions a more important determinant of quality within industries. So, relocation across industries could seriously underestimate total changes in relocation occurring after trade liberalisation. Consider again Table 1b. By pooling the data, we cannot reject at the 5 % level the hypothesis that the coefficients for market size are the same in the three years. However, the coefficient for human capital clearly increases from 1969 to 1981/1994. So, concentration of production does not seem to change over time, but lower trade costs lead to increased specialization according to factor proportions. We also distinguished between horizontal and vertical IIT. An increased share of vertical IIT would suggest a greater concentration of production in different qualities within industries.

According to both the narrow and broad definitions, HIIT increased substantially as a share of total trade between 1969 and 1981 (its share of total trade increased by 52 % according to HIIT1 and by 79 % according to HIIT2). Then, it stagnated and according to HIIT2 fell somewhat. As in the U.K. case, vertical IIT is always higher than horizontal IIT even when the relatively broad wedge of ±25 % is used. The share of vertical IIT increased between 1969 and 1994 according to both definitions.[15] The increase is more pronounced using VIIT1. With this measure, it also increased between 1969 and 1981 and again to 1994. When we instead measure vertical IIT by means of the broader wedge of +-25 %, the share of VIIT decreased somewhat between 1969 and 1981. Clearly, HIIT seems to have increased in importance between 1969 and 1981, but then stagnated. So, we hardly find evidence of recent increased dispersion of production within industries. But, whether we can conclude that production is getting more concentrated is more difficult.

We also examined the coefficient of variation in import prices. In a, albeit, fairly small majority of cases it increased from 1969 to 1981 as well as from 1981 and 1994, suggesting some evidence of specialisation in different qualities within industries. More specifically, in 58% of the industries price dispersion increased between 1969 and 1981 and in 54 % between 1981 and 1994. So, although the evidence on vertical

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[15] Two objections could however be made. First, the distinction of VIIT as defined by price differences of ±15% and +25 % is essentially arbitrary. But when we compare VIIT vs. HIIT over time, the exact cut-off points should not matter too much. Moreover, we have initially used two cut-off points and also experimented with others and the results are similar. Second, one could argue that the fact that Swedish VIIT has increased is driven by changes in Swedish qualities rather than by different countries increasingly exporting products of different qualities. To some degree, this is true. The quality of Swedish exports relative to its imports have increased somewhat from 1.80 in 1969 to 2.09 in 1981 and 2.14 in 1994. However, this could also be interpreted as an indication that vertical IIT could not increase too much in Sweden, since that, already in 1969, Sweden was specialized in the production of high-quality varieties.

and horizontal IIT is somewhat ambiguous, there is other evidence that some concentration of production has occurred.

6. CONCLUSIONS

A large part of world trade is IIT. Although a large number of studies have asked why the share of bilateral trade is higher in some trade and for some countries and industries than for others, few studies have attempted to examine the determinants of the product pattern of trade. So this was the first aim of the present study. Given data constraints we restricted ourselves to the Swedish case on the assumption that imports to Sweden are representative of total exports for the OECD countries. The first question we asked was whether economic geography or H-O-S comparative advantage factors were more important in predicting trade within industries. It turned out that, largely, the answer was both! A large domestic market, and an abundant endowment of human capital increases the quality of exports. Moreover, the results seem to be very robust.

The second aim of the paper was to ask whether concentration of production within industries has increased, so that different countries increasingly specialise in the production of different qualities. Here, the evidence is less clear-cut. We have computed the coefficient of variation in import prices, but no clear tendency emerges. There is some evidence that vertical IIT increases over time, whereas horizontal IIT has stagnated but this evidence is too weak to offer support for this aspect of geography models.

In sum, the results are very promising. Both economic geography and factor proportions variables seem to be important in determining trade within industries.

There is, of course, a lot more research which could be done. First, one could attempt to determine how much trade within industries is explained by economic geography relative to that by factor proportions. This could either be done for all manufacturing, or for individual industries. Moreover, there is the likelihood that there are industry characteristics that make economic geography more important in some industries and factor proportions more important in others. Also, in evaluating the importance of comparative advantage one should in principle not only focus on factor proportions but remember that technology differences have recently been shown to be important. This could prove to be important also for explaining trade flows within industries as suggested by e.g. Flam and Helpman (1987) and Davis (1995). It would be useful to find ways of testing the hypothesis that has been put forward by Davis (1995): that (small) technical differences within industries could cause IIT and predict a determinate pattern of trade within industries.

References

Abd-el-Rahman, K. (1991), “Firms' competitive and national comparative advantages as joint determinants of trade composition”, *Weltwirtschaftliches Archiv*, Vol. 127, pp. 83-97.

Baldwin, R.E. and Venables, A.J. (1995) “Regional Economic Integration”. In: Grossman, G.M. and Rogoff, K. *Handbook of International Economics*, Elsevier, Amsterdam.

Barro, R.J. and J.W. Lee (1996), ”International Measures of Schooling Years and Schooling Quality”, *American Economic Review*, Vol. 86, pp. 218-223.

Brülhart, M. and J. Torstensson, “Regional Integration, Scale Economies and Industry Location in the European Union”, CEPR Discussion Paper 1435.

Davis, D. (1995), “Intra-Industry Trade: A Heckscher-Ohlin-Ricardo Approach”, *Journal of International Economics.*

Davis, D. and D.E. Weinstein, (1996) “Does Economic Geography Matter for International Specialisation?”. *NBER Working Paper*, No. 5706.

Deardorff, A.V., (1979), "Weak Links in the Chain of Comparative Advantage", *Journal of International Economics*, Vol. 9: 197-209.

Deardorff, A.V. (1982), "The General Validity of the Heckscher-Ohlin Theorem", *American Economic Review*, Vol. 72: 683-694.

Dixit, A.K. and J.E. Stiglitz, (1977) “Monopolistic Competition and Optimum Product Diversity”. *The American Economic Review*, vol. 67, pp. 297-308.

Falvey, R (1981) ”Commercial policy and intra industry trade”, *Journal of International Economics*, Vol. 11, pp. 495-511.

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

Flam, H., & Helpman, E., (1987), "Vertical Product Differentiation and North-South Trade", *American Economic Review*, Vol 77: 810-822.

Fontagne, L., Freuedenberg, M. And Pèridy, N. (1997), Trade Patterns Inside the Single Market”, CEPII, Document de Travail, No 97-07.

Fujita, M and Thisse, J.F. (1996), "Economics of Agglomeration", *Journal of the Japanese and International Economies*, Vol. 10, 339-378.

Gabszewicz, J.J., Shaked, A., Sutton, J. and Thisse, J.F. (1981): "International Trade in Differentiated Products", *International Economic Review*, Vol, 22, 527-533.

Greenaway, D., Hine, R.C. and C.R. Milner, C.R. (1994), ”Country-specific factors and the pattern of horizontal and vertical intra-industry trade in the UK”, *Weltwirtschaftliches Archiv*, Vol. 130, pp. 77-100.

Greenaway, D. Hine, R.C. and C.R. Milner, (1995) 'Vertical and Horizontal Intra-Industry Trade: A Cross-Industry Analysis for the United Kingdom', *Economic Journal*, Vol. 105, pp. 1505-1519.

Greenaway, D. and Milner, C.R., (1986) *The Economics of Intra-Industry Trade.* Basil Blackwell, Oxford.

Greenaway, D. and Milner, C.R. (1987) “Intra-Industry Trade: Current Perspectives and Unresolved Issues”, *Weltwirtschaftliches Archiv*, Vol. 123, pp. 39-57.

Greenaway, D. & Torstensson, J. (1997), ”Back to the Future: Taking Stock on Intra-Industry Trade”, *Weltwirtschaftliches Archiv*, Vol. 133, No. 2.

Grossman, G. and E. Helpman (1991), *Innovation and Growth in the Global Economy,* MIT Press, Cambridge, Mass.

Hanson, G. (1997), ”Increasing Returns, Trade and the Regional Structure of Wages, *Economic Journal*, vol. 107, pp. 113-133.

Hansson, P. (1993), ”Product Quality and Vertical Differentiation as Determinants of Intra-Industry Trade in Swedish Manufacturing”, FIEF Working Paper No. 122.

Harrigan, J. (1996), ”Technology, Factor Supplies, and International Specialization: Estimating the Neoclassical Model”, Federal Reserve Bank of New York, Staff Reports, No 15.

Helpman, E. (1987), ‘Imperfect Competition and International Trade: Evidence from Fourteen Industrialised Countries’, *Journal of Japanese and International Economics*, Vol. 1.

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

Hummels, D. and Levinsohn, J. (1995) Monopolistic Competition and International Trade: Reconsidering the Evidence, *Quarterly Journal of Economics*, Vol. 110, pp. 799-836.

Klepper, S. and Leamer, E.E. (1984) Consistent Sets of Estimates for Regressions with Errors in All Variables, *Econometrica,* Vol. 52, pp. 163-183.

Krugman, Paul (1980) “Scale Economies, Product Differentiation, and the Pattern of Trade”. *American Economic Review*, vol. 70, pp. 950-959.

Krugman, Paul (1991a) “Increasing Returns and Economic Geography”. *Journal of Political Economy,* vol. 99, pp. 483-499.

Krugman, Paul (1991b) *Geography and Trade*, MIT Press, Cambridge (Mass.).

Krugman, Paul and Venables, Anthony J. (1995) “Globalization and the Inequality of Nations”. *Quarterly Journal of Economics,* vol. 110, pp. 857-880.

Leamer, E. and Levinsohn, J. (1995) International Trade Theory: The Evidence, in *Handbook of International Economics, Vol. III,* North-Holland, Amsterdam.

Markusen, J.R. and Venables, A.J. (1996) The Theory of Endowment, Intra-Industry and Multinational Trade, *CEPR Discussion Paper No. 1341,* February 1996.

Torstensson, J. (1991) Quality differentiation and factor proportions in international trade: an empirical test of the Swedish case, *Weltwirtschaftliches Archiv,* Vol. 127, pp. 183-94.

Torstensson, J. (1996a), Determinants of intra-industry trade: A sensitivity analysis, *Oxford Bulletin of Economics and Statistics,* Vol. 58, No.3.

Torstensson, J. (1996b), Can factor proportions explain vertical intra-industry Trade?, *Applied Economics Letter*s.

Venables, A.J., (1987), "Trade and Trade Policy with Differentiated Products: A Chamberlinian-Ricardian Model", *Economic Journal,* Vol. 97: 700-717.

Table 1a: Regression Results; Individual Years

Variable	**1969**	**1981**	**1994**
HCAP	0.108 (3.72)	0.257 (9.99)	0.274 (6.91)
PCAP	-0.0005 (-0.01)	-0.156 (-3.85)	0.072 (1.54)
MARKSIZE	0.097 (8.58)	0.095 (8.49)	0.111 (8.65)
n	2313	2572	2597

heteroscedasticity-consistent *t*-statistics within parantheses.

Table 1b: Regression Results; Panel data

Variable	Restricted Coefficients	Slope-dummies	European dummy
HCAP	0.204 (12.28)	0.110 (3.64)	0.100 (5.17)
PCAP	-0.036 (-1.50)	-0.019 (-0.48)	0.059 (2.32)
MARKSIZE	0.093 (13.14)	0.093 (7.84)	0.049 (6.40)
HCAP81		0.145 (3.80)	
HCAP94		0.164 (3.34)	
PCAP81		-0.137 (-2.46)	
PCAP94		0.089 (1.41)	
MARKSIZ81		0.001 (0.06)	
EUROPE			-0.62 (10.53)
MARKSIZ94		0.018 (0.99)	
n	7482	7482	7482

heteroscedasticity-consistent *t*-statistics within parantheses.

Table 2: Vertical (VIIT) and Horizontal (HIIT) Intra-Industry Trade as Percentage of Total Trade

Year	HIIT1	HIIT2	VIIT1	VIIT2
1969	0.077	0.125	0.319	0.270
1981	0.117	0.224	0.356	0.249
1994	0.126	0.208	0.389	0.305

Table 3: Robust Regressions

Variable	1969	1981	1994	Pooled
HCAP	0.120 (4.95)	0.278 (11.54)	0.269 (10.42)	0.222 (14.52)
PCAP	0.0001 (0.96)	-0.122 (-2.46)	0.086 (2.32)	-0.022 (-1.22)
MARKSIZE	0.110 (10.22)	0.108 (10.52)	0.109 (11.20)	0.098 (14.43)
n	2313	2572	2597	7482