No. 1435

REGIONAL INTEGRATION, SCALE ECONOMIES AND INDUSTRY LOCATION IN THE EUROPEAN UNION

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INTERNATIONAL TRADE

Centre for Economic Policy Research

ISSN 0265-8003

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Discussion Paper No. 1435
July 1996

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ABSTRACT

Regional Integration, Scale Economies and Industry Location in the European Union*

This paper analyses the effects of regional integration on the location of increasing-returns industry and the resulting pattern of trade. Theoretically, it is shown that regional integration may initially lead to a dispersion of industry inside the customs union. Below a certain threshold of internal trade costs, however, industry concentration in the central member country will again increase. This non-monotonic relationship with regional integration also applies to equilibrium levels of intra-industry trade (IIT). A strictly monotonic negative relationship is found between, on one hand, the degree of scale economies and, on the other hand, industrial concentration both in the central country and intra-union IIT. Empirical evidence for the European Union lends support to some of the theoretical predictions. Employment in scale-intensive industries tends to be concentrated at the centre of the EU, and IIT is relatively low in these sectors. An IIT growth reversal is detected for the scale-intensive industries, which supports the non-monotonicity predicted by the model.

JEL Classification: F12, F15, R12
Keywords: regional integration, economic geography, European Union, scale economies

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*This paper is produced as part of a CEPR research programme on *Market Integration, Regionalism, and the Global Economy*, supported by a grant from the Ford Foundation (no. 920–1265). We are grateful to Karolina Ekholm, Dermot McAleese, Geoff Reed, Tony Venables and participants in the

International Economics Group at Lund University and at the Trade Union Institute for Economic Research, Stockholm, for valuable comments. This research was supported by the Stimulation Plan for Economic Sciences in the European Union (SPES–CT91–0058) and by the Swedish Council for Research in the Humanities and Social Sciences (HSFR).

Submitted 23 May 1996

NON-TECHNICAL SUMMARY

Interest in the location of manufacturing production has recently been revived both in academic circles and among policy-makers. This is due in part to *theoretical* developments, where international trade theory has been combined with insights from industrial economics and economic geography. Another reason has been the *empirical* development of trade liberalization in Europe and elsewhere, which has stimulated thinking about the locational forces unleashed by such policies.

In the context of European integration, some, mainly neoclassical, economists and policy-makers subscribe to the belief that the 'peripheral' countries stand to reap the greatest relative gains in terms of manufacturing production. The new theoretical models, on the other hand, suggest that manufacturing production may become more concentrated at the 'centre'. Some empirical evidence has been invoked to illustrate the validity of the new theories. Paul Krugman, for example, has compared industrial concentration in the United States and in Europe and found that industries are more localized in the former. This might suggest that further integration would lead to more geographical concentration in Europe as well.

What economic geographers refer to as the 'concentration' or 'localization' of industries, is likely to be called 'inter-industry specialization' by a trade economist. The opposite scenario can be named interchangeably 'locational dispersion' or 'intra-industry specialization'. If trade propensities of firms in particular industries are similar across countries, intra-industry *specialization* will be closely related to intra-industry *trade* (IIT). Numerous econometric exercises suggest that regional integration affects the share of IIT positively, but some recent studies have found a tendency for IIT to stagnate or even decrease in certain EU countries and industries.

Theoretical predictions and empirical evidence on this topic are still patchy and inconclusive. Theoretical work has mostly used two-country models. In order to examine the issue of *regional* integration, we need a model with at least three countries: two countries to analyse what happens inside the preferential trading area and one outside country to examine interaction with the rest of the world. Moreover, remarkably little empirical work on industrial location has been undertaken in this context.

Our analysis differs from earlier studies in two ways. First, we present a theoretical model with three countries, and we examine the effects of

integration among two of them. We focus on the equilibrium location of manufacturing production and equilibrium levels of IIT with different degrees of scale economies and at various stages of economic integration. Second, we produce empirical evidence for the EU and thereby evaluate the relevance of the theoretical model.

The *theoretical analysis* shows a non-monotonic relationship between regional integration and the geographical concentration of increasing-returns industry. A reduction of intra-union trade costs tends to lead to a higher dispersion of production within the customs union (CU) if initial intra-union trade costs are high. Thus, the formation of a CU is initially expected to reduce the degree of industrial localization at the centre. Below a certain threshold of intra-union trade costs, however, geographical concentration of industry tends to increase with further integration, so that the locational centre-periphery gradient is accentuated by the reduction of trade costs. Moreover, our analysis predicts that the tendency of an industry to locate at the centre of the CU increases monotonically in the industry's degree of scale economies.

There is a direct link between the theoretical predictions on industry location and those on IIT. The non-monotonicity result is upheld. IIT generally increases at early stages of regional integration, but decreases when intra-union trade costs fall below a certain threshold. An industry's degree of scale economies relates negatively to its equilibrium level of intra-union IIT.

The results of our *empirical study*, conducted on employment and trade data for the European Union, largely conform with the predictions of the model and therefore indicate that the new theories are relevant. Based on the calculation of locational Gini indices from EU employment statistics for 1980 and 1990, we find that increasing-returns industries tended to be highly localized. Cross-country and cross-region correlations suggest that these industries are concentrated in central EU countries and regions.

Grouped analyses of highly disaggregated IIT coefficients show that increasing-returns industries are subject to relatively low IIT. These industries also exhibit a reversal of intra-EU IIT growth in the 1980s. By subdividing increasing-returns industries by the importance of intra-EU non-tariff barriers (NTBs), we find that sectors subject to low NTBs display below-average IIT levels throughout the 1960–90 period and a pronounced reversal of IIT growth in the 1980s. Considering that these are the industries which are likely to have been most strongly affected by the abolition of intra-EU *tariff* barriers, their IIT path is suggestive of a non-monotonic relationship between integration and industry concentration.

The results of this paper are of considerable policy relevance, particularly for the debate on the regional effects of the Single Market. One might infer that further reductions of trade costs in Europe could lead to considerable centripetal shifts in European industry. Under this scenario, we would expect increased concentration of scale-intensive production at the core of the EU, whereas the periphery would specialize in manufacturing activities not characterized by scale economies and in non-manufacturing activities. This would imply a stagnation or even reduction in the share of IIT in total trade among EU countries. Such a development might pose considerable structural adjustment problems.

Our calculations indicate that much of the scale-driven concentration process in European manufacturing has already taken place, however. There appears to remain greater scope for inter-industry specialization in industries which are mainly sensitive to other locational determinants, such as factor costs. In the United States it is in traditional, relatively small-scale industries that the most pronounced locational clustering has been detected. Our results show that these sectors are still relatively dispersed in the EU, and these activities seem poised to experience locational shifts towards peripheral countries. This scenario would gain particular relevance in the event of an eastward enlargement of the EU.

I. Introduction

Interest in the location of manufacturing production has recently been revived both in academic circles and among policy makers. This is due in part to *theoretical* developments, where international trade theory has been combined with insights from industrial economics and economic geography. Another reason has been the *empirical* development of trade liberalisation in Europe and elsewhere that has stimulated thinking about the locational forces unleashed by such policies.

In the context of European integration, some, mainly neo-classical, economists and policy makers subscribe to the belief that the "peripheral" countries stand to reap the greatest relative gains in terms of manufacturing production. The new theoretical models, on the other hand, suggest that manufacturing production may become more concentrated at the "centre". Some empirical evidence has also been invoked to suggest that industries may cluster geographically when trade costs are reduced. Krugman (1991) has compared industrial concentration in the United States and in Europe and found that industries are much more concentrated in the former. This could suggest that further integration would lead to more concentration also in Europe, hence that a "true" United Europe would look much more like the United States. Under such a scenario, trade among EU countries would no longer consist mainly of a two-way exchange in similar products within the same industry, so-called *intra*-industry trade (IIT), but become increasingly *inter*-industry in nature.

However, the extant literature on this topic is still patchy and inconclusive. Theoretical work has mostly used two-country models. In order to examine the issue of *regional* integration, we need a model with at least three countries: two countries to analyse what happens inside the preferential trading arrangement and one outside country to examine interaction with the rest of the world. Moreover, remarkably little

empirical work on industrial location has been undertaken.[1] This is a major gap in the literature, especially since the theoretical models do not always offer conclusions that are even qualitatively clear-cut, and empirical work is therefore needed to complement the theoretical enquiry.

This analysis differs from earlier studies in two ways. First, we present a theoretical model with three countries, and we examine the effects of integration among two of them. We focus on the equilibrium location of manufacturing production at various stages of economic integration, and we analyse the predictions of the model in terms of equilibrium IIT with different degrees of scale economies and trade costs. Second, we produce empirical evidence for the European Union and thereby evaluate the relevance of the theoretical model. The empirical results largely conforms to the predictions of the theoretical model.

The paper is organised as follows. In Section II, we present the theoretical model and derive four testable hypotheses. Section III reports the empirical exercise. In Section IV, we summarise the main findings and add some concluding comments.

II. The Model[2]

Consider a model with one factor of production (labour) and three countries. Without loss of generality, we can choose units so that there is one unit of labour in country I, "the rest of the world". In country II, there are β units of labour, and the endowment

[1] There is a growing literature on convergence of aggregate income and productivity across countries and regions (on regional convergence in the EU, see Neven and Gouyette, 1995) and a number of case studies have been conducted on the locational shifts of individual sectors. Little research effort has been devoted, however, to the simultaneous exploration of these processes across industries and countries.

[2] For a more elaborate presentation of the theoretical model, see Torstensson (1995).

of labour in country III equals α units. Countries II and III will form a customs union (CU). We further assume that $\beta > \alpha$, so that we can call country II the "centre" and country III the "periphery" of the CU.[3] One industry, Y, produces homogeneous products under constant returns to scale (CRS). We can call this industry "agriculture". The remaining industries, X_i, produce horizontally differentiated manufactured goods under increasing returns to scale (IRS). For the sake of simplicity, it is assumed that zero transport costs prevail in industry Y.[4]

We follow Helpman and Krugman (1985) in assuming trade impediments of an "iceberg" type in manufacturing industries X_i, where only a certain proportion of each exported unit is received by the importer. These impediments should be thought of as a composite of various man-made and physical trade barriers that can be reduced (or increased) but not totally removed by policy measures. We define $1/\tau_i$ $(\tau_i > 1)$ as the fraction of differentiated products that "arrive" at the importers in bilateral trade flows between countries I-II and I-III in industry X_i, whereas $1/\varsigma_i$, $(\tau_i > \varsigma_i > 1)$ $1/_i$, $(\varsigma_i > 1)$ is the fraction of products that arrive at the importers in trade flows between countries II and III in industry X_i. A CU is conventionally defined as an absence of tariffs and quotas among member countries that also apply a common external tariff. In our model, there is a common external trade barrier, but positive internal trade barriers persist even after formation of the CU between the "centre" and the "periphery".

We suppose that the typical household has a utility function given by the conventional Cobb-Douglas upper-tier utility function and Spence-Dixit-Stiglitz subutility functions.

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[3] Baldwin and Venables (1995) and Puga and Venables (1995) examine other aspects of regional integration and market size. See also Ethier and Horn (1994) for an early analysis of regional integration in a model with monopolistic competition.

[4] Allowing for transport costs in the CRS sector changes the magnitudes of the effects predicted by this model, but does not reverse the qualitative results (see Calmette and Le Poitier, 1995).

$$(1) \qquad U_x = \sum_l \Big(\sum_{i=1}^{n} x_i^{\varepsilon_l}\Big)^{\gamma_l/\varepsilon_l} \; Y^{1-\Sigma\gamma_l}, \;\; 0<\varepsilon_l<1, \; \varepsilon_l = 1-(1/\sigma_l)$$

where x_{li} is consumption of variety l in industry X_i, and Y is consumption of the homogeneous product.[5] The substitution elasticities, σ_i, are thus allowed to differ across IRS industries.[6]

It then follows that aggregate demand for the total of manufacturing industry i products produced in the three regions equals:[7]

(2)-(4)

$$D_1 = n_1 x = \left[n_1 p_1^{-\sigma}\gamma / \left[n_1 p_1^{1-\sigma} + n_2(p_2\tau)^{1-\sigma} + n_3(p_3\tau)^{1-\sigma}\right]\right] +$$
$$\left[\, n_1(p_1\tau)^{-\sigma}\gamma\beta\tau / \left[n_1(p_1\tau)^{1-\sigma} + n_2 p_2^{1-\sigma} + n_3(p_3\varsigma)^{1-\sigma}\right]\right] + \quad ,$$
$$\left[\, n_1(p_1\tau)^{-\sigma}\gamma\alpha\tau / \left[n_1(p_1\tau)^{1-\sigma} + n_2(p_2\varsigma)^{1-\sigma} + n_3 p_3^{1-\sigma}\right]\right]$$

$$D_2 = n_2 x = \left[n_2(p_2\tau)^{-\sigma}\gamma\tau / \left[n_1 p_1^{1-\sigma} + n_2(p_2\tau)^{1-\sigma} + n_3(p_3\tau)^{1-\sigma}\right]\right]$$
$$+\left[\, n_2 p_2^{-\sigma}\gamma\beta / \left[n_1(p_1\tau)^{1-\sigma} + n_2 p_2^{1-\sigma} + n_3(p_3\varsigma)^{1-\sigma}\right]\right] + \quad ,$$
$$\left[\, n_2(p_2\varsigma)^{-\sigma}\gamma\alpha\varsigma / \left[n_1(p_1\tau)^{1-\sigma} + n_2(p_2\varsigma)^{1-\sigma} + n_3 p_3^{1-\sigma}\right]\right]$$

$$D_3 = n_3 x = \left[n_3(p_3\tau)^{-\sigma}\tau / \left[n_1 p_1^{1-\sigma} + n_2(p_2\tau)^{1-\sigma} + n_3(p_3\tau)^{1-\sigma}\right]\right] +$$
$$\left[\, n_3(p_3\varsigma)^{-\sigma}\gamma\beta\varsigma / \left[n_1(p_1\tau)^{1-\sigma} + n_2 p_2^{1-\sigma} + n_3(p_3\varsigma)^{1-\sigma}\right]\right] + \quad ,$$
$$\left[\, n_3 p_3^{-\sigma}\gamma\alpha / \left[n_1(p_1\tau)^{1-\sigma} + n_2(p_2\varsigma)^{1-\sigma} + n_3 p_3^{1-\sigma}\right]\right]$$

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[5] In this model, the number of varieties is constant and trade liberalisation only affects the location of production.

[6] Since the demand and production functions are identical in all manufacturing industries (except, of course, for the parameter values), we can henceforth omit the industry subscripts in manufacturing.

[7] See Helpman and Krugman (1985, p. 206).

where p_j is the price of varieties produced in country j (equal for all varieties produced in each country, since they enter the utility function symmetrically and since they are produced with the same technology).[8]

The cost functions are the same for all firms. Production of each variety of the IRS-good incurs a fixed cost and constant marginal cost. In this context output per firm (x) will be constant (see Venables, 1987). Since we assume that both countries produce the CRS-good and that technologies are identical, the wage rate and the price of the IRS-products must also be equalised.

The Analysis

Let us divide both sides of the three equations (2)-(4) by n_1, n_2 and n_3 respectively. Furthermore, we choose units so that $w=p=1$ and define $\rho = \tau^{1-\sigma} < 1$, $\delta = \varsigma^{1-\sigma} < 1$. Note that ρ and δ decrease in trade impediments (since $\sigma > 1$) and increase in the degree of equilibrium scale economies.

[8] Note that there is an indirect demand for products used up through trade impediments. That is, we have to multiply the foreign demands by ς and τ, respectively.

Rewriting (2)-(4) then yields:

$$
\begin{aligned}
& x/\gamma = [1/(n_1 + n_2\rho + n_3\rho)\ ] + [(\beta\rho)/(n_1\rho + n_2 + n_3\delta)\ ] + [(\alpha\rho)/(n_1\rho + n_2\delta + n_3)\ ] \\
\textit{(5-7)}\quad & x/\gamma = [\rho/(n_1 + n_2\rho + n_3\rho)\ ] + [\beta/(n_1\rho + n_2 + n_3\delta)\ ] + [(\alpha\delta)/(n_1\rho + n_2\delta + n_3)\ ] \\
& x/\gamma = [\rho/(n_1 + n_2\rho + n_3\rho)\ ] + [(\beta\delta)/(n_1\rho + n_2 + n_3\delta)\ ] + [\alpha/(n_1\rho + n_2\delta + n_3)\ ]
\end{aligned}
$$

Equations (5)-(7) can be solved to yield the number the varieties in each country as:

(8)-(10)

$$n_1 = \gamma\left[\left[2\rho - \delta - 1)\rho(\alpha + \beta)\ \right] - (\rho - 1)(\delta + 1)\right] / \left[x(\rho - 1)(2\rho - \delta - 1)\ \right]$$

$$n_2 = \gamma\left[\alpha(\rho^2 - \delta)(2\rho - \delta - 1) + (1 - \rho)(\beta(2\rho^2 + \rho(1 - \delta) - \delta - 1) + \rho(1 - \delta))\ \right] / \left[x(\rho - 1)(\delta - 1)(2\rho - \delta - 1)\ \right]$$

$$n_3 = \gamma\left[\alpha(2\rho^3 - \rho^2(\delta + 1) - 2\rho + \delta + 1) + \beta(\delta - \rho^2)(2\rho - \delta - 1) + \rho(1 - \delta)(\rho - 1)\ \right] / \left[x(1 - \delta)(\rho - 1)(2\rho - \delta - 1)\ \right]$$

We restrict our analysis to the case where all countries have positive production in all industries.

Regional Integration and the Location of Manufacturing: The "U-curve"

What are the effects of a lowering of trade costs between the "centre" and "periphery" on the location of manufacturing production? By taking the partial derivatives of equations (8)-(10) with respect to δ, we arrive at:

(11)-(13)

$$\partial n_1 / \partial\delta = -2\rho\gamma / (x(2\rho - \delta - 1)^2)$$

$$\partial n_2/\partial\delta = -\gamma(\alpha(4\rho^3 - 4\rho^2\delta + \rho(\delta - 3)(\delta + 1)) + (\delta + 1)^2)$$
$$-\beta(4\rho^3 - 4\rho^2\delta + \rho(\delta - 3)(\delta + 1) + (\delta + 1)^2) - \rho(\delta^2 - 2\delta + 1))/(x(2\rho - \delta - 1)^2(\delta - 1)^2)$$

$$\partial n_3/\partial\delta = \gamma(\alpha(4\rho^3 - 4\rho^2\delta + \rho(\delta - 3)(\delta + 1)) + (\delta + 1)^2) -$$
$$\beta(4\rho^3 - 4\rho^2\delta + \rho(\delta - 3)(\delta + 1) + (\delta + 1)^2) - \rho(\delta^2 - 2\delta + 1))/(x(2\rho - \delta - 1)^2(\delta - 1)^2)$$

The results concerning the CU-members (II and III) offer some interesting insights.[9] Internal liberalisation effectively enlarges the domestic market of CU members and therefore yields re-location of IRS industries from the outside world to the CU. Looking at the distribution of IRS activity within the CU, it emerges that the *initial formation* of a CU leads to an increase in the absolute size of manufacturing production in the large CU country and to an ambiguous effect on manufacturing production in the small CU country.[10] The competitiveness of the centre increases both within the union and towards the outside country. The increased competitiveness of the "periphery", towards the rest of the world (through access to the larger joint market) may or may not be outweighed by its lower competitiveness vis-à-vis the core of the CU.

The algebraic derivation of general results is fraught with difficulties because of the non-monotonic relationships illustrated by equations (11)-(13). If we take the whole spectrum of potential intra-CU trade costs, trade costs are always related non-monotonically to the locational attraction of the small CU country. There is an interval of intra-union trade costs where location becomes more dispersed with a fall in trade costs, but this relationship is reversed below a certain threshold of intra-CU trade costs.

The non-monotonic relationship between regional integration and industrial production in the small member country is illustrated in Figure 1, which plots the

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[9] Note that this is a comparative static exercise which tracks equilibrium configurations accompanying the reduction of trade costs, but omits transitory adjustment mechanisms.

[10] This can be demonstrated by taking the partial derivatives of equations (11)-(13) with respect to δ and evaluating them at the initial point where non-discrimination applies (with $\rho = \delta$):

$$\partial n_1 / \partial \delta = -2\rho\gamma / [\ x(\rho-1)^2\ ]$$

$$\partial n_2 / \partial \delta = \gamma[\ \rho+(\rho+1)(\beta-\alpha)\ ] / [\ x(\rho-1)^2\ ]$$

$$\partial n_3 / \partial \delta = \gamma[\ \rho+(\rho+1)(\alpha-\beta)\ ] / [\ x(\rho-1)^2\ ]$$

share of CU industrial production located in the central country ($n_2 / (n_2 + n_3)$) against various levels of intra-CU trade costs for one particular configuration of the remaining parameters. A "u-curve" emerges: concentration in the "centre" will initially decrease with integration. However, as intra-union trade costs are lowered beyond the position of the "hump" in the curve, dispersion of production is reversed, as production becomes again more localised at the centre.

What intuition underlies this "u-curve"? Regional integration has two relevant effects on the peripheral country. First, the periphery gains locational attractiveness *vis-à-vis the rest of the world* due to its improved access to the combined CU market; but, second, it simultaneously loses competitiveness *vis-à-vis the central country*, since lower trade costs exacerbate the locational advantage of the country with a larger home market.[11] If the rest of the world is large, and intra-CU barriers are relatively high, then the first effect is likely to dominate the second: increased competitiveness for the periphery towards the outside country outweighs the loss of competitiveness towards the partner country. As regional integration continues, relocation from the rest of the world to the CU leads to a fall in the relative size of industry in the rest of the world. Simultaneously the competitive advantage of the central CU country relative to the periphery increases. Hence, there is a critical point of regional integration where the second effect comes to dominate the first, and the size of peripheral industry shrinks relative to that of central industry.

The relationships distilled from our model can be interpreted both in an intertemporal and in a cross-sectional sense. We have tracked equilibrium industry location at gradually falling intra-EU trade costs. In a world of instantaneous and costless re-location of production, this represents the locational dynamics under regional

[11] On the second effect, see Brülhart (1995).

integration. Another interpretation is to consider differences in trade costs across industries. Then, our analysis suggests a tendency for industrial concentration in industries with high trade costs, dispersion of industries with intermediate trade costs, and strongest concentration in industries with low trade costs.[12]

We can summarise the predictions of our model in a first set of hypotheses:

H1: For a large class of parameter values on scale economies and extra-union trade costs, equilibrium location of industry relates non-monotonically to intra-union trade costs. In a certain interval, reduction of intra-union trade costs leads to a higher dispersion of production within the CU. However, below a certain threshold of intra-union trade costs geographical concentration of industry increases with further reductions of these trade costs.

Conditions for Non-Monotonicity

The emergence of the "u-curve" is contingent on certain parameter values.[13] The combination of relative country sizes and scale economies can be such that the "hump" occurs not in the relevant interval of positive intra-CU trade costs that are lower than those for extra-union trade, but either at a point of negative trade costs or

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[12] This, of course, only holds for the large class of parameter values which give rise to a non-monotonic relationship between intra-CU trade costs and industry location in the peripheral country.

[13] The development illustrated in figure 1 is a fairly general one. However, in certain cases the "periphery" has initially zero production of manufacturers and will only with reduced intra-union trade costs start producing manufacturing products. In other cases, when the two member countries are large compared to the rest of the world, intra-union competion is of such an importance that the periphery's share of manufacturing production will monotonically fall. But, we should note that if we allowed for true general equilibrium effects so that product prices could change, the picture we present would be an even more general one. We have, following Krugman and Venables (1990), experimented with sector-specific capital in agriculture (in this case, we allow only for one manufacturing industry) so that when labour leaves such production, its marginal product and thus the wage rate increases. This dampens (but only modify our conclusions) specialisations, leaving further room for production in the "periphery", still giving us a U-shaped relationship that we can observe in a larger number of cases (but where the subsequent fall of periphery's production at low trade costs is less dramatic).

where trade costs are lower in extra-union trade. In these cases we observe that dispersion of production will rise or fall monotonically.

We can solve for the critical threshold of intra-union trade costs at which the share of manufacturing production in the periphery will begin to fall. These results are illustrated in Figure 2, based on the assumption that the sizes of countries II and III are equal to $\beta = 0.2, \alpha = 0.15$. We choose parameter values for ρ between 0.0625 and 0.5. To arrive at these values we combine elasticities of demand between 2 and 5 if we assume that as much as 50 percent of export is lost in trade ($\tau = 2$). If only one third of total production is lost in exports ($\tau = 1.5$), demand elasticities lie between 2.7 and 8.6. Thus, the higher is the degree of scale economies and the lower are extra-CU trade costs, the lower is the "hump" threshold value of intra-CU trade costs.

Industry Location and Scale Economies

Instead of varying intra-CU trade costs and tracking equilibrium industry location *ceteris paribus*, we can change the degree of scale economies and hold all other variables constant. In this case, no non-monotonicity arises, as concentration unambiguously increases in the degree of scale economies. Figure 3 depicts the share of production in the centre of the CU ($n_2/(n_2+n_3)$) as a function of trade costs and scale economies/elasticity of demand (*ELDEM*). The underlying parameter values are as follows: $\beta = 0.8; \alpha = 0.5; \tau = 1.7$(high trade costs), $\tau = 1.5$ (low trade costs). However, unambigous conclusions apply to all parameter values.[14] Figure 3 illustrates that concentration is increasing in scale economies (note, again, that scale economies and elasticity of demand are perfectly inversely related). Thus, industries with a low

[14] The results are clear-cut as shown by a very large number of simulations, but difficult to arrive at analytically since both δ and ρ change with changes in the degree of scale economies.

degree of scale economies will, other things equal, tend to be dispersed, while scale-intensive industries tend to be highly localised.[15]

We therefore arrive at a second set of hypotheses:

H2: Industries with a high degree of scale economies are the most localised. This localisation occurs at the "centre" of the customs union.

Regional Integration and Intra-Industry Trade

What economic geographers refer to as the "concentration" or "localisation" of industries, a trade economist is likely to call "inter-industry specialisation". The opposite scenario can be named interchangeably "locational dispersion" or "intra-industry specialisation". If trade propensities of firms in a particular industries are similar across countries, intra-industry specialisation will be closely related to intra-industry trade (IIT). Numerous econometric exercises suggest that regional integration affects the share of IIT positively but some recent studies have found a tendency for IIT to stagnate or even decrease in certain countries and industries.[16]

IIT is commonly measured by the Grubel-Lloyd (GL) index. In bilateral trade between countries *j* and *k*, it is equal to:

$$(14) \quad GL_{jk} = [\ 2\min(D_{jk}, D_{kj})\ ] / [D_{jk} + D_{kj} + T_Y\ ]$$

[15] Moreover, a strictly monotonic relation also exists between location and country size. Large differences in country size strengthen the locational attraction for IRS industries to the "centre". However, in the EU context, relative "centre" and "periphery" measures do not seem to have changed significantly over time (see Section III).

[16] For a comprehensive survey of empirical IIT research see Greenaway and Milner (1986). The partial stagnation of IIT growth has been reported by Greenaway and Hine (1991) and Brülhart and Elliott (1996).

where D_{jk} is demand in country j for differentiated goods in industry i produced in country k.[17]

Given the constant relationship between industrial dispersion and IIT, it should be obvious that the "u-curve" between intra-union trade costs and *industry location* also appears between intra-CU trade costs and *IIT* (although we may in certain extreme cases have either continuously increasing or decreasing shares of IIT). Figure 4 illustrates equilibrium intra-CU IIT shares, based on the initial parameter values $\beta = 0.2, \alpha = 0.15, \tau = \varsigma = 2, \sigma = 4$.

We can formulate a new set of hypotheses:

H3: For a large class of parameter values on scale economies and extra-union trade costs, the level of intra-industry trade between the CU countries relates non-monotonically to intra-union trade costs. Under these configurations, equilibrium intra-industry trade rises at early stages of regional integration, but decreases when intra-union trade costs fall below a certain threshold.

Since there is a constant positive relation between industrial dispersion and IIT, the example illustrated in Figure 3 also suggests a negative relationship between scale economies and IIT. Therefore, we can formulate a fourth hypothesis:

H4: The degree of scale economies relates negatively to intra-union IIT, ceteris paribus.

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[17] Net export in industry i from country j to country k in each IRS-good is therefore given by $(D_{ikj} - D_{ijk})$. From the demand equations obtained by inserting the equilibrium number of firms from (8)-(10) in (2-4), each country's multilateral net export in the IRS-good can be determined. In turn, given the assumption of balanced multilateral trade, this determines the export of the CRS good in bilateral trade flows.

Our theoretical analysis has offered us with four (sets of) hypotheses, two relating to industry location and two concerning IIT. Their empirical relevance is explored in the next section, based on data for the European Union.

III. Empirical Analysis: Industry Location and Intra-Industry Trade in the European Union

Country Size and Centrality in the European Union

In the model set out above, we distinguished between the "centre" and the "periphery" of the CU. The empirical counterpart of this theoretical concept is captured by the centrality index proposed by Keeble *et al.* (1986), who evaluated the accessibility of 166 EU regions using the following definition:[18]

$$(15) \quad P_i = \sum_j \frac{Y_j}{D_{ij}} + \frac{Y_i}{D_{ii}}; \; i \neq j,$$

where i is the relevant region, j stands for all other EU regions, $Y_{i,j}$ is 1983 regional gross domestic product, D_{ij} measures the shortest road distance[19] between the largest settlements in regions i and j, and D_{ii}, the "intra-regional distance cost", is defined as "one-third of the radius of a circle of the same area as region i". In order to obtain estimates of the centrality of EU countries, we have aggregated these indices for the 12 EU members, weighting them by 1983 regional population.[20]

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[18] Keeble *et al.* (1986) have referred to this coefficient as the "peripherality index". Since this measure relates negatively to the peripherality of a region, we term it "centrality index" for clarity.

[19] Where regions are separated by water, weighted values of ferry costs were applied.

[20] We apply the same centrality indices to a number of years spanning a period of three decades. It might be argued that such an analysis is invalid, because it does not take account of shifts in relative peripherality. However, there are strong indications that the economic geography of European regions has remained remarkably stable. Begg and Mayes (1994) have re-calculated centrality indices of the EU regions for 1977, 1983, 1985, 1989 and 1990, using the Keeble methodology, and they detected only marginal changes over time. It thus seems appropriate to apply unchanged centrality indices for the different years of our data sample.

Scale Economies Across Industries

In the variable δ of our model, scale economies interact with trade costs. It is no easy task to capture this variable empirically, and proxies used in previous empirical analyses have often not been related very closely to theoretical concepts of scale economies. In a careful attempt to estimate scale economies, Pratten (1988, p. 2-70) compiled a ranking of manufacturing industries "in order of the importance of economies of scale for spreading development costs and for production costs", where the degree of scale economies is determined by "products and production runs" and "size of the establishment".[21] There is thus a clear correspondence between this empirical classification and the theoretical concept of internal scale economies.[22]

Industry Location and Scale Economies in the EU

In order to capture the degree of concentration or dispersion of EU industrial sectors, we have calculated "locational Gini indices" measuring the locational structure of manufacturing employment, as suggested by Krugman (1991). These indices can take values between 0 and 1. A high Gini index suggests a high degree of inter-industry specialisation. Where the Gini index is (close to) zero, a sector is not localised, but spread out in line with total manufacturing employment.

Columns (2) and (4) of Table 1 report locational Gini indices for the distribution of 18 industries among 11 EU countries in 1990 and 1980. Industries are ranked in decreasing order by the level of their locational Gini index in 1990. We compare our listing by Gini indices to the ranking of industries by scale economies taken from

[21] For other measures of scale economies, see Torstensson (1996a, b).

[22] Note that the Pratten (1988) classification distinguishes a mere twenty industries. These are bound to be subject to considerable heterogeneity in terms of underlying production requirements. Our data set is thus likely to conceal considerable differences within "industries". Currently available statistics, however, do not allow a more disaggregated analysis.

Pratten (1988) and reported in column (1) of Table 1. There appears to be some correlation between locational concentration of an industry and the importance of increasing returns. The eight industries featuring at the top of the ranking by Pratten (1988) also feature first in our ranking by Gini index. The Spearman rank correlation between the IRS rank and the Gini rank equals 0.69, which is statistically significant at the 1% level. This finding supports the prediction of our model, formulated as part of our second hypothesis, that IRS industries will cluster geographically.

Our second hypothesis predicts that IRS industries will concentrate *in the "centre"*. Pearson correlation coefficients between the centrality of a country and the employment share of a particular industry in that country are reported in columns (3) and (5) of Table 1. These coefficients are taken as indicators of locational bias towards the central countries, since the higher their value, the larger is the employment share of a particular industry in central countries relative to its share in the manufacturing employment of peripheral countries. Comparing columns (3) and (5) with the ranking by scale economies of column (1), we detect a strong correlation between an industry's potential for scale economies and its locational bias towards the central countries of the EU. The rank correlation between the industry ranking by scale economies (column 1) and a ranking by centre-periphery bias (column 3) equals 0.63, which is statistically significant at the 1% level. Increasing-returns industries thus appear to be located in central EU countries.

Given the positive correlations between scale economies and both localisation and centre-periphery bias, it is not surprising that the two latter variables also correlate. Comparing columns (2) and (4) with columns (3) and (5), we detect a positive relationship between the degree of locational concentration, measured by the Gini index, and location in the central EU countries. Industries which are highly localised, therefore, appear to be located predominantly in central EU countries.

Entire countries, however, could be ill-suited locational units on which to base our analysis. We therefore supplement our investigation by the analysis of a regional data set, drawing on published statistics for nine EU countries and seven of the 18 sectors covered in Table 1. The results are reported in Table 2. They confirm our findings obtained from country data. The greater the importance of scale economies, the more strongly industries were concentrated in central EU regions both in 1976 and in 1985.

Hypothesis 1 suggests that, after a certain interval, the attraction of large countries is enhanced by the dismantling of trade barriers. This effect is difficult to measure empirically, due to the impossibility of isolating integration-induced changes. Inspection of the last row in Table 1 also shows that industry has become more localised during the 1980s (rising Gini coefficients). However, it should be noted this appears not to have been biased in favour of central countries (falling correlations with centrality). The degree of concentration in central EU countries of industries subject to high scale economies does not seem to have increased during the 1980s.

There are two plausible scenarios in which these results are compatible with the model outlined above. First, it is conceivable that the main steps of economic integration in the EU (corresponding to a fall in ς) have occurred previous to the period covered by our data. CU formation and the first EU enlargement might have removed the principal obstacles to intra-EU trade in industrial goods, and induced the current concentrated locational structure of IRS sectors. Under such a scenario, the forces described by our model would have been unleashed in the 1950s to 1970s, and relatively little further concentration of IRS industry should be anticipated. Alternatively, it could be hypothesised that remaining non-tariff barriers continued to

segment EU markets in the 1980s (yielding a significant ς) and were only dismantled gradually by the Single Market programme.[23] Under that scenario, the locational forces emphasised in our model might be an important determinant of industrial adjustment following the implementation of the Single Market.

Intra-Industry Trade and Scale Economies in the EU

Our model suggests a close correspondence between the level of IIT and the dispersion of industries. This section therefore draws on a set of highly disaggregated IIT measures for 12 EU countries. The indices are calculated from SITC 4 and 5-digit statistics, where the underlying number of manufacturing "industries" ranges between 365 (1961) and 2169 (1990).[24]

According to our fourth hypothesis, the proportion of IIT will decrease in an industry's degree of scale economies. Based on the classification by Pratten (1988), we find in Table 3 that industries with high and intermediate economies of scale exhibit consistently lower IIT than industries with low scale economies. The "scale intensive" industries identified by the OECD (1987) also display consistently and significantly lower IIT than the average. These results are is in line with a number of previous studies which have found a negative relationship between scale economies and IIT, and it supports the prediction of our model .[25]

The results of Table 3 furthermore suggest that post-War growth in intra-EU IIT has been reversed in the scale-sensitive industries in the 1980s. The detected rise and

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[23] It is well known that, following the two oil crises in the 1970s, non-tariff barriers among EU countries tended to increase (see e.g. Greenaway, 1983). This development contributed to the impetus behind the Single Market initiative.

[24] For details on data sources and transformations see the Appendix.

[25] Econometric studies which found a negative association between scale economies and IIT include Loertscher and Wolter (1980), Greenaway and Milner (1984), Balassa and Bauwens (1987), Ray (1991) and Somma (1994). For a sensitivity analysis of the relationship, see Torstensson (1996).

subsequent fall of IIT in those industries is suggestive of a "hump-shape" development of these industries in peripheral EU regions as predicted by the third hypothesis derived from our theoretical model. Relative expansion of IRS sectors in peripheral EU countries during the early periods of European integration appears to have been followed by a relative contraction in the 1980s. Moreover, IIT in the whole sample has shown some tendency to stagnate offering support for out third hypothesis of a hump-shaped relationship between IIT and intra-union trade costs. [26]

Intra-Industry Trade and Economic Integration

Our empirical results are suggestive of a negative relationship between IIT and scale economies. Strictly speaking, our theoretical model shows that trade costs interact with scale economies in determining the share of IIT. We can get a qualitative handle on intra-union trade costs through the work of Buigues *et al.* (1990). Based on that classification, we have categorised our IIT into one group of industries subject to significant non-tariff barriers (NTBs) and one group of industries with low NTBs. These two categories were further divided into two subcategories by the importance of scale economies, according to Pratten (1988), and IIT averages were calculated for each of the four industry groups.[27] The results are reported in Figure 5.

The first result to note is that the split of the total sample into high NTB and low NTB industries (not represented in Figure 5) produces no statistically significant differences of IIT means for any of the six sample years. In Figure 5, we see that this

[26] The non-monotonic development of intra-EU IIT in IRS industries might be attributed to the revision of the SITC code of 1988, which significantly increased the number of separate 5-digit industries, and hence be discarded as a statistical artefact. We calculated ratios of pre-revision to post-revision industry numbers for each of the three categories, and found that it was largest in the "intermediate" category, but that it was lower in the "high" category than in the "low" category. Hence, at least the relative fall of average IIT in the "high" category cannot be explained by statistical re-classification.

[27] For details of our classification procedure, see the Appendix.

also applies to the industry category subject to low scale economies, where the split by NTBs has no statistically significant impact on observed IIT averages.[28]

As expected from the theory, NTBs appear to matter for the IRS industries. In the 1960s, IRS industries subject to low NTBs displayed significantly lower intra-EU IIT than IRS industries with high NTBs and these industries also displayed the most pronounced "hump-shaped" evolution of IIT.[29]

IV. Concluding Remarks

Our theoretical model, which is derived from the widely used monopolistic-competition framework underlying the "new" theories of trade and economic geography, has produced a number of topical hypotheses.

The empirical study, conducted on employment and trade data for the European Union, largely conforms with the predictions of the model.[30] We find that increasing-returns industries tend to be highly localised, concentrated in central EU countries and

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[28] One implication of this result is that the relatively low levels of IIT found to prevail in IRS industries do not stem from the possibility that IRS industries could be subject to above-average trade impediments, and that the latter reduce IIT. NTBs do not appear to affect IIT levels systematically, hence the categorisation by scale economies seems to be an independent source of differences in IIT patterns.

[29] These differences are statistically significant at the 0.01 level in 1961 and at the 0.05 level for 1967 (ANOVA).

[30] Our empirical results are largely in line with the theoretical predictions. However, it should still be pointed out that our empirical findings do not correspond perfectly to the predictions of our model. Figure 4 shows that the model predicts the liberalisation-induced decrease in IIT to be more rapid where scale economies are low. In Table 3, we see that industries subject to low scale economies have generally displayed above-average and growing IIT levels in the EU. This lack of correspondence between the theory and empirical results may be due to the restrictive nature of our one-factor model. In the real world, some of the adjustment to lower trade barriers will come through higher wages in the "centre". This will tend to counteract the centripetal forces of increasing returns and the minimisation of transport cost and favour a sustained dispersion of IRS activity (and hence IIT) even at very low intra-union trade costs.

subject to relatively low IIT. These industries have also been subject to a reversal of intra-EU IIT growth in the 1980s. The results of this paper are of considerable policy relevance, particularly for the debate on the regional effects of the Single Market. One might infer that further reductions of trade costs in Europe can lead to considerable centripetal shifts in European industry. Under this scenario, we would expect increased concentration of scale-intensive production at the core of the EU, whereas the periphery would specialise in manufacturing activities not characterised by scale economies and in non-manufacturing activities. This would imply a stagnation or even decrease in the share of IIT in total trade among EU countries. Such a development might pose considerable structural adjustment problems.

However, our calculations indicate that much of the scale-driven concentration process in European manufacturing has already taken place. There appears to remain greater scope for inter-industry specialisation in industries which are mainly sensitive to factor costs. It is in traditional, relatively small-scale industries that Krugman (1991) has detected the most pronounced locational clustering in the United States. Our results show that these sectors are still relatively dispersed in the EU, and locational shift of these activities seem more likely to benefit peripheral countries. This scenario would gain particular relevance in the event of an eastward enlargement of the EU.

In spite of their remarkable consistency, our findings should be considered as suggestive rather than conclusive. The empirical exercise is subject to several statistical constraints. The level of industry disaggregation of our employment data is relatively low, so that these "industries" are likely to group together quite heterogeneous activities. While the degree of statistical disaggregation of our trade data is much more satisfactory, our explanatory variables do not match that level of precision. In particular, we only avail of qualitative measures of our explanatory

variables, hence a parametric exercise was not feasible. Our exercise implicitly assumes that the relative degrees of increasing returns accross industries do not change over time, since no data are available on changes in minimum efficient plant scales. Furthermore, the similarity of our findings with the predictions of the model is no proof that the locational forces identified in the theory are the main determinants of the detected employment and trade shifts. For instance, temporary re-location rigidities of scale-sensitive industries can produce the same non-monotonic path of integration-induced industry re-location and IIT as the one predicted by the three-country model of this paper (see Krugman and Venables, 1990; and Brülhart, 1995). This obviously leaves considerable scope for further research.

Table 1

Locational Concentration and Centre-Periphery Structure of Industrial Employment in EU Countries

			1990		1980		1980-90
		(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
NACE	Industry description	Rank by scale economies[1]	Locational Gini coefficient	Locational bias towards centre[2]	Locational Gini coefficient	Locational bias towards centre[2]	Change in Gini coefficient (%)
37	Instrument engineering	9	0.392	-0.01	0.402	0.17	-3
32	Mechan. engineering	7	0.370	0.55*	0.320	0.59*	15
35	Motor vehicles	1	0.344	0.63**	0.270	0.60*	28
33	Office, data processing	6	0.328	-0.05	0.312	0.15	5
34	Electrical engineering	8	0.316	0.72**	0.254	0.87***	25
36	Other transp. equipm.	2	0.288	0.21	0.238	-0.04	21
22	Metals	5	0.242	0.30	0.188	-0.24	29
25/6	Chemicals	3/4	0.230	0.75***	0.178	0.77***	29
31	Misc. metal articles	12	0.228	0.40	0.192	0.29	19
48	Rubber and plastics	13	0.226	0.57*	0.174	0.62**	29
44	Leather goods	20	0.212	-0.42	0.150	-0.63**	42
46	Timber and furniture	18	0.202	-0.47	0.206	-0.45	-2
49	Misc. manufactures	16	0.198	0.12	0.194	0.16	2
47	Paper and printing	10	0.192	0.22	0.208	0.20	-7
43	Textiles	17	0.170	-0.60**	0.106	-0.64**	60
41/2	Food, drink, tobacco	14/5	0.162	-0.58*	0.176	-0.54*	-8
45	Clothing and footwear	19	0.148	-0.74***	0.096	-0.79***	54
24	Non-metallic minerals	11	0.122	-0.82***	0.100	-0.78***	20
	ALL		0.188	0.60*	0.156	0.62*	21

[1]Ranking by decreasing "importance of economies of scale for spreading development costs and for production costs", by Pratten (1988, p. 2.70).

2Pearson correlation coefficients between $(E_i / \Sigma E_i)_j$ and C_j, where E_i denotes employment in the manufacturing sector i, j is the country subscript, C stands for the centrality index. Statistical significance (t tests, N=11): 0.01: ***, 0.05: **, 0.1: *.

Table 2

Centre-Periphery Structure of Industrial Employment in EU Regions

NACE	Industry Description	Rank by scale economies	Number of observations	Locational bias towards central regions, 1985	Locational bias towards central regions, 1976
35	Motor vehicles	1	72	0.39***	0.40***
25/6	Chemicals	3	80	0.23*	0.31**
33	Office, data proc.	6	34	0.09	0.16
37	Instrument engin.	9	70	0.13	0.09
43	Textiles	17	88	-0.09	0.14
45	Clothing, footwear	19	76	-0.42***	-0.19*
44	Leather goods	20	65	-0.28**	-0.32**

Data source: Eurostat regional statistics. For further explanation see footnotes to *Table 1*.

Table 3

Trends in Intra-Industry Trade Among EU Countries in Different Industry Categories[1]

	Whole Sample	High scale economies (Pratten)	Intermed. scale ec. (Pratten)	Scale intensive (OECD)
Industries	*98*	*20*	*33*	*26*
IIT, 1961	0.35	0.32 (2.4)	0.29 (16.7)***	0.29 (7.0)***
IIT, 1967	0.41	0.38 (2.7)	0.36 (12.4)***	0.35 (8.8)***
IIT, 1972	0.43	0.40 (3.0)*	0.39 (7.4)***	0.38 (7.6)***
IIT, 1977	0.47	0.44 (1.8)	0.44 (2.7)*	0.42 (6.4)**
IIT, 1985	0.47	0.45 (1.8)	0.46 (1.4)	0.43 (6.4)**
IIT, 1990	0.46	0.42 (4.7)**	0.44 (2.8)*	0.41 (8.4)***

[1] IIT are unadjusted Grubel-Lloyd indices for manufactures trade (SITC 5-8) among the EU12, calculated from SITC 4-digit (1961, 67) and 5-digit data, aggregated to the SITC Rev. 1 3-digit level (98 industries), unweighted averages across countries. Figures in brackets are *F*-ratios of analysis of variance on null hypothesis that category mean is equal to sample mean (statistical significance: 0.01: ***, 0.05: **, 0.1: *).

Figure 1
The "U-curve": Industry Concentration and Regional Integration

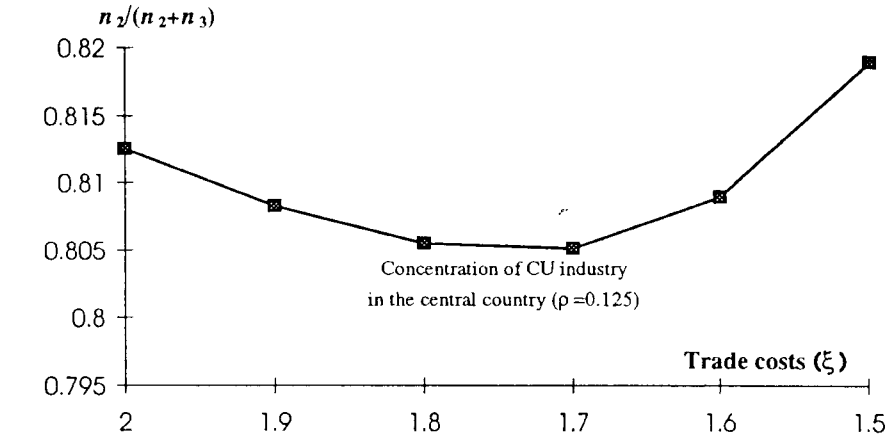


Figure 2
Critical Values of the "Hump"

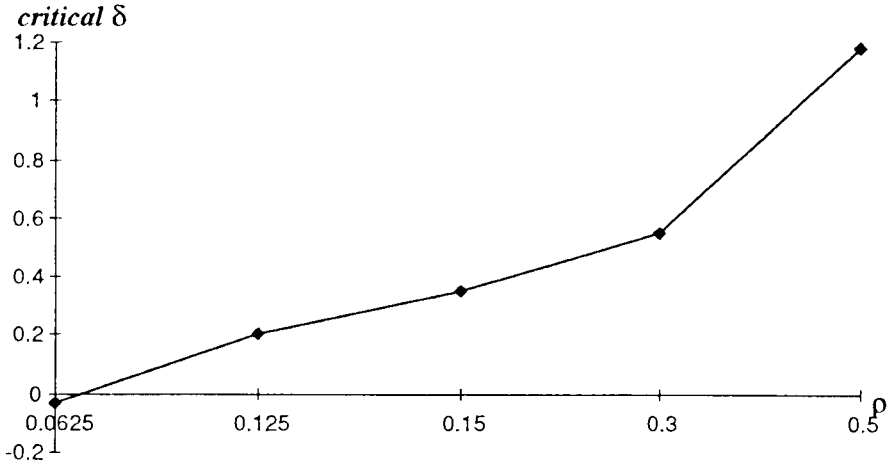


Figure 3
Concentration, Scale Economies and Trade Costs

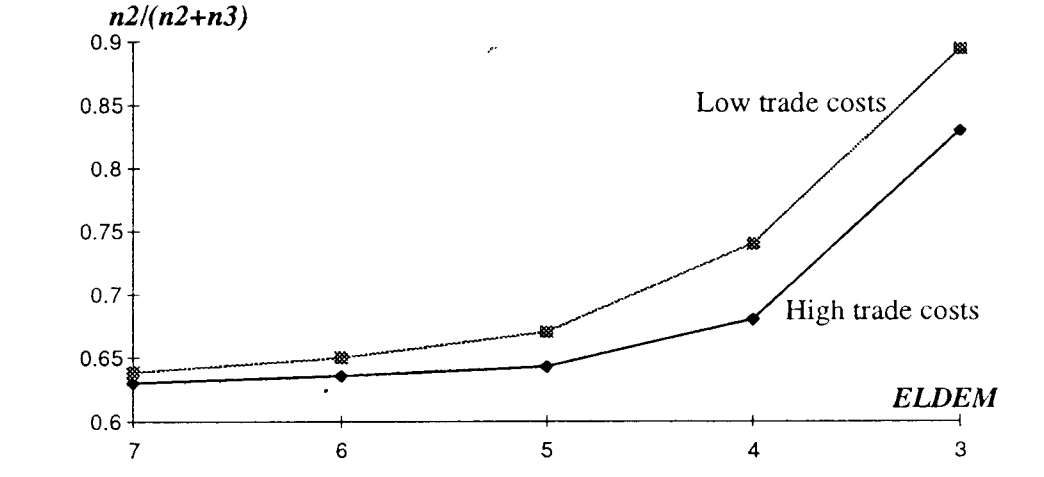


Figure 4
Intra-Industry Trade and Economic Integration

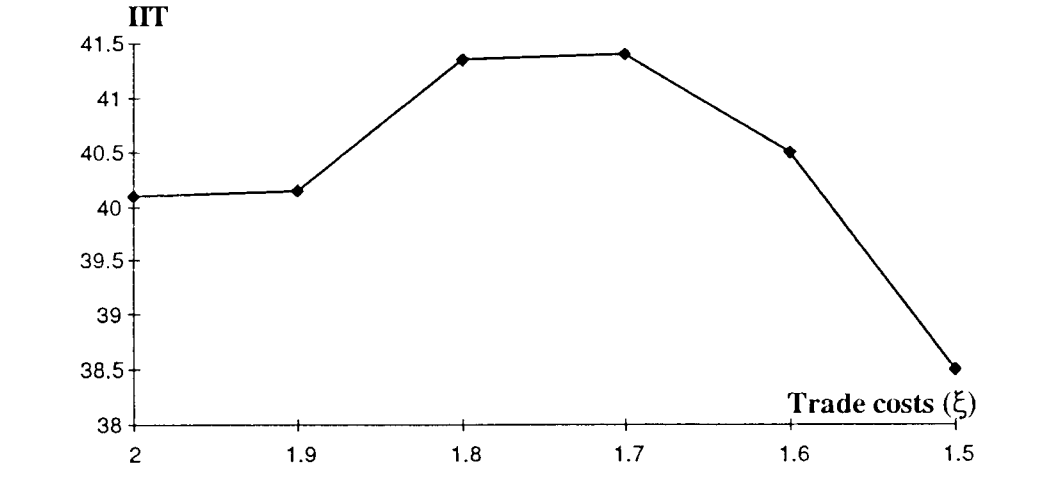
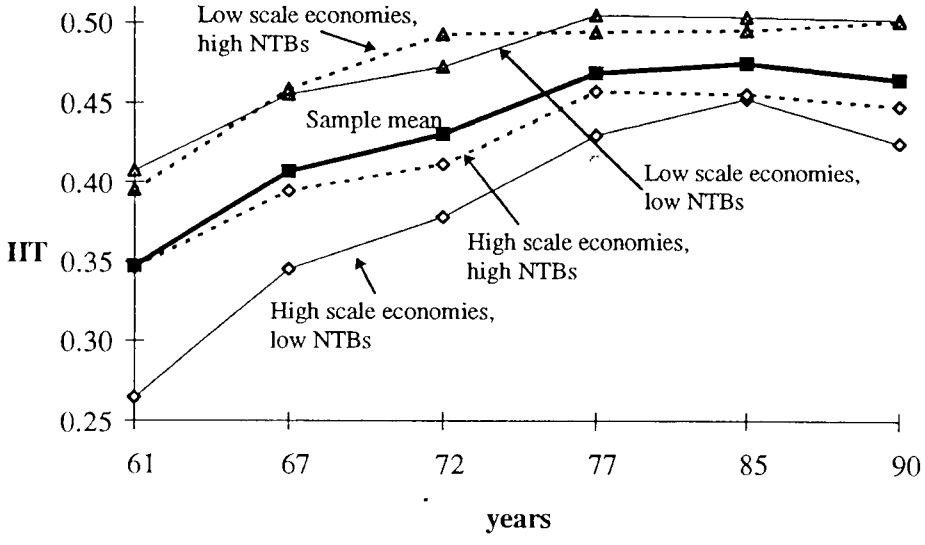


Figure 5

Intra-Industry Trade, Scale Economies and Non-Tariff Barriers Among EU Countries



For information on data sources and transformation see the Appendix.

Appendix

The centrality indices underlying Table 1 are calculated from the regional indices reported by Keeble *et al.* (1986, p. 29ff.). We chose the indices adjusted by the authors for purchasing-power parity exchange rates and aggregated them for each country, weighting the indices by 1983 regional population taken from Eurostat regional statistics. The employment figures for the 18 NACE sectors underlying the results of Table 1 were taken from Eurostat's annual industrial structure statistics. Gaps in these data were filled with estimates based on industry statistics published by the OECD.

Our IIT data are taken from a database created by the participants of the SPES research network on "Trade, Specialisation and Market Structure in the EC" between 1992 and 1995.

In the SPES database, the IIT indices are aggregated to and reported at the SITC 3-digit level. Since the SITC product classification was revised twice over the period covered in our study, we re-arranged all the SPES indices into SITC Revision 1 product groups, based on United Nations (1961, 1986), so that changes in the IIT indices over time could be tracked industry by industry.

In order to calculate the results reported in data columns 2 to 4 of Table 3, four of the 98 industries of our data set had to be eliminated, because they could not be allocated to any of the three categories of scale economies. The categories are based on the "Ranking of Manufacturing Industry Groups by Economies of Scale" in Pratten (1988, p. 2-70). Our "high" category contains the first four of the 20 industries in Pratten's table (Motor Vehicles, Other Vehicles, Chemicals and Man-Made Fibres). Our "intermediate" category consists of the sectors ranked 5 to 9 in Pratten (1988) (Metals, Office Machinery, Mechanical Engineering, Electrical Engineering and Instrument Engineering). Since the industries in Pratten's table are based on the NACE classification, they had to be identified among our SITC sectors using a NACE-SITC concordance table. 20 SITC industries were attributed to the "high" category, 33 to the "intermediate" category and 41 to the "low" category. Underlying the results reported on the right-hand side of Table 5 is the classification in ISIC 2-digit and 3-digit product groups compiled by the OECD (1987, p. 29ff.).

The "high scale economies" industries of Figure 5 comprise the "high" and "intermediate" categories based on the Pratten (1988) classification. The sectors subject to intra-EU NTBs were identified on the basis of Buigues *et al.* (1990, p. 24) and a NACE-SITC concordance table. The category with high scale economies and high NTBs comprises 25 industries, the category with high scale economies and low NTBs comprises 28 industries, the category with low scale economies an high NTBs comprises 12 industries, and the category with low scale economies and low NTBs comprises 29 industries.

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