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Integration, specialization, and adjustment

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Abstract

The paper considers the location of two industries in two countries. Both industries are imperfectly competitive, producing goods for final consumption and use as intermediates. Intermediate usage creates cost and demand linkages between firms, encouraging industrial agglomeration. With high trade barriers each industry operates in both locations in order to supply final consumers. At lower trade barriers agglomeration forces dominate and each industry concentrates in a single location. Economic integration therefore induces agglomeration. There are long run gains from integration, but during the adjustment process some of the labour force may suffer lower real wages as relocation of industry occurs.

JEL classification: F1; F12; F15; R3

Keywords: Industrial location; Integration; Agglomeration

1. Introduction

Geographers have long noted the importance of 'industrial districts' in interregional specialization. In many industries firms tend to cluster together, drawn by the availability of a local base of specialized suppliers (often including labour with specialized skills); this local base in turn owes its existence to the local concentration of demand. Thus a circular process of agglomeration takes place. Historical industrial districts include such famous examples as the Detroit-centred automo-

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tive region and the New York garment industry; today the phenomenon is perhaps best represented by California's Silicon Valley and Boston's Route 128.

Unlike geographers, economists studying international trade have traditionally paid little attention to the role of industry agglomerations as a cause of specialization (with the notable exception of Ohlin (1933), who used the jewelry concentration in Solingen to illustrate the role of increasing returns). This neglect may in part be a theoretical blind spot: before 1980 trade theorists were reluctant to address the role of increasing returns in any form, and the post-1980 literature on 'intraindustry' trade initially emphasized internal as opposed to external economies of scale. The neglect of agglomeration may also, however, have been a realistic judgement. While industrial districts like the auto region have obviously played a crucial role in interregional specialization, their role in international trade is less apparent. For example, the European automotive industry never developed a single hub comparable to Detroit.

There is no mystery about why agglomeration has been a more potent force for interregional than for international specialization. Barriers to trade between national economies – both formal barriers such as tariffs and the de facto barriers created by differences in language and culture, lack of factor mobility, and the sheer nuisance presented by the existence of a border – are often enough to block the expansion of a successful industrial district beyond its national market. For this reason, industries within Europe are in general much less geographically concentrated than their counterparts within the United States. Table 1 offers some examples, exploiting the fact that the four major US regions are roughly comparable in population and income to the four large European economies. It is obvious that in each case production is far more localized in the US.

As Europe becomes a more highly integrated economy, so it is developing the conditions under which one might expect some industries to serve the market from a single local agglomeration rather than from many sources. This prospect raises several questions. First, where will the industrial districts of 21st century Europe be located? That is, which country will get Europe's Silicon Valley, its Wall Street, and so on? Second, will the formation of such districts be beneficial to the European economy? Finally, how will the adjustment take place – if an industry

Table 1
Shares of industry employment

	United States (1990)				Europe (1989)			
	Northeast	Midwest	South	West	France	Germany	Italy	UK
Steel	13.4	51.8	24.5	10.4	18.9	20.2	18.7	15.8
Autos	7.9	65.6	23.4	7.0	25.3	34.7	9.5	13.0
Textiles	14.2	3.2	79.6	3.9	15.8	13.2	17.4	18.6

Source: OECD employment statistics.

that currently has several national centres coalesces around a single European centre, what happens to the workers left behind?

This paper makes a first step toward answering these questions by developing a stylized theoretical model of the relationship between industrial agglomeration and international trade. The model is closely related to recent work in economic geography papers, however, it assumes that factors are immobile between countries. Following Venables (1996), we find that vertical linkages among industries can play a role in industrial specialization similar to that played by factor mobility in more aggregate agglomeration stories. In particular, we find that increased integration – a reduction in the costs of doing business across space – somewhat paradoxically makes it more likely that firms in the same industry will cluster together.

While this paper was inspired by the issues surrounding European integration, we believe that the model is of broader interest. It offers a novel perspective on the forces driving international specialization and trade. And we believe that this model, in which strongly nonlinear dynamics emerge as a natural consequence of the economic analysis, illustrates the likely importance of such dynamics in economic modelling more broadly.

2. The model

Imagine a world in which there are several industries, in each of which both goods intended for final consumption and intermediate goods are produced subject to economies of scale. Imagine also several countries with similar resources and technology. Suppose, however, that initially transport costs between these countries are very high. Then each country will maintain the full range of industries, producing both final goods and the intermediate inputs into those final goods. There may be some intraindustry trade in differentiated products, but there will be no process of interindustry specialization. But now suppose that transport costs fall to a lower level. Then a country with a strong initial position in some industry may find itself with an advantage that cumulates over time. Producers of final goods will find that the country with the larger industry supports a larger base of intermediate producers, which gives them low enough costs to export to other markets; producers of intermediate goods will find that it is to their advantage to concentrate their production near the large final good industry. Thus each industry will tend to concentrate in one of the countries. The result, somewhat paradoxically, will be that greater integration will lead countries to become more different.

This is a simple and intuitively plausible story, but it is not that easy to formalize. Indeed, a formal model of this process must contain what may at first seem a daunting number of features. It must have an input–output structure with several classes of both final and intermediate goods; it must involve increasing returns, and therefore must deal with the problem of imperfectly competitive

market structure; and it must introduce transport costs. To make such a model tractable we rely on a series of modelling tricks. These include the familiar devices of the 'new trade theory', namely assuming special functional forms and symmetry at several levels.

We assume, then, a world in which there are two countries, Home and Foreign. The countries are symmetric. We will write the equations describing Home's tastes and technology, and simply note that the same equations apply to Foreign; where Foreign variables occur they will be denoted *. Consumers in each country divide their expenditure equally between two symmetric industries. Each industry produces differentiated products, and we follow the common Dixit and Stiglitz (1977) representation of product differentiation. For each industry we therefore define a price index, Q_i, over the prices of individual varieties supplied. This takes the form

$$Q_i = \left[n_i p_i^{1-\sigma} + n_i^* \left(p_i^* \tau \right)^{1-\sigma} \right]^{1/(1-\sigma)}, \quad i = 1,2, \tag{1}$$

where n_i and n_i^* are the number of varieties of industry i product produced in Home and Foreign, p_i and p_i^* are prices charged for each variety, and τ are iceberg trade costs; to deliver one unit of any good from one country to another $\tau > 1$ units must be shipped.

Production in each industry uses a composite input (to be defined below) which costs C_i per unit. The total costs of a firm in industry i are $C_i[\alpha + \beta x_i]$ where α is the fixed input requirement, and β is input per unit of output produced by each firm, x_i. Each industry is monopolistically competitive, and each firm sees itself as facing constant elasticity of demand σ, so sets price

$$p_i = C_i \beta\sigma/(\sigma - 1). \tag{2}$$

The zero profit condition establishes a size of firm which is independent of C_i:

$$x = (\sigma - 1)\alpha/\beta. \tag{3}$$

The input used in each industry is a Cobb–Douglas composite of labour and intermediate goods produced in both industries, and its unit cost, C_i, is given by

$$C_i = w_i^{1-\mu-\nu} Q_i^{\mu} Q_j^{\nu}. \tag{4}$$

w_i is the wage rate in sector i, and μ and ν describe the input–output technology of the economy. μ is the share of costs spent on intermediates produced in the same industry, and these intermediates are differentiated products with price index Q_i; ν is the share of costs spent on intermediates from the other industry, with price index Q_j.[1] The two industries are symmetric, in the sense that parameters α, β, μ, ν, and σ are the same in both industries.

[1] We employ the simplifying assumption that the same price index aggregates differentiated products used as final goods in consumption and intermediate goods in production.

Each country is endowed with one unit of labour. Labour may be employed in either industry but does not move instantaneously between industries; wages in each industry may therefore differ. Proportion $1-\mu-\nu$ of costs and hence of revenue go to labour, so employment levels and numbers of firms in each industry are linked by the equation

$$w_i L_i = (1-\mu-\nu) n_i p_i x. \tag{5}$$

Income is simply the sum of wages earned in each sector:

$$Y = w_1 L_1 + w_2(1-L_1). \tag{6}$$

What matters for industry location is not, however, aggregate income but expenditure on that industry's products. This is consumers' expenditure (half of income) plus demand for intermediates. Since shares μ and ν of the value of industry sales is spent on intermediates, we may write the Home expenditure on industry i as

$$E_i = 0.5Y + \left[\mu w_i L_i + \nu w_j (1-L_i)\right]/(1-\mu-\nu). \tag{7}$$

Sales of Home-based firms in industry i can be shown to be

$$x_i = p_i^{-\sigma}\left[E_i Q_i^{\sigma-1} + E_i^* (Q_i^*/\tau)^{\sigma-1}\right]. \tag{8}$$

Firms make zero profits if x_i reaches the scale x given in Eq. (3).

In the short run levels of employment in each industry in each country are fixed. Eqs. (1)–(8), and analogous equations for Foreign, characterise the short-run equilibrium, implying wage rates in each industry and country. Workers are internationally immobile, but can change industry internally. We hypothesise an ad hoc rule under which workers move gradually toward the industry that offers the higher wage. Long-run equilibrium obtains when, within each country, wages in both industries are equal.

3. Dynamic behaviour

We begin exploring the model's dynamics with a series of figures constructed from numerical examples. We assume, crucially, that intra-industry input–output linkages are stronger than inter-industry $\mu > \nu$. Fig. 1 illustrates the case of high transport costs. The dimensions of the box are home labour force (horizontal) and foreign (vertical), and employment in industry 1 is measured from the bottom left corner. The curve $L_1^* = 0$ is the locus along which $w_1 = w_2$, and the dashed curve is analogous for foreign, $w_1^* = w_2^*$. Evidently there is a long-run equilibrium at point S, with both industries divided equally between countries. Below the curves industry 1 is small, so $w_1 > w_2$, $(w_1^* > w_2^*)$ and the direction of reallocation of labour between sectors is given by the arrows. It is immediately apparent that in this high-transport-cost case the allocation of resources always converges to the symmetric outcome, S. That is, this figure illustrates a 'European' outcome in

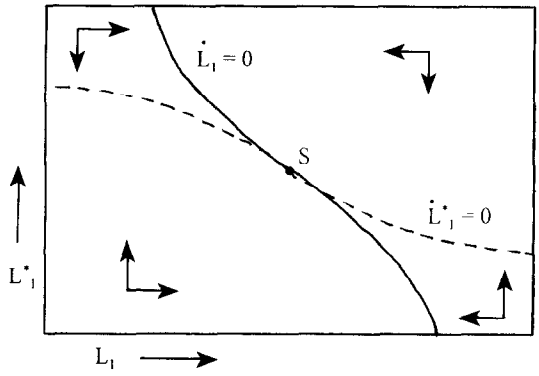

Fig. 1. High τ.

which the backward and forward linkages are not strong enough to lead to agglomeration.

Fig. 2 shows the contrary case, in which transport costs are much lower. The system is saddle-path unstable: except along a knife-edge path that leads to S, each industry will end up completely concentrated in one country, i.e. at either A_1 or A_2. That is, this figure illustrates the 'American' outcome in which highly localized industries serve the whole continental market.

Are these the only possible cases? No: for intermediate values of τ we have the more complex picture illustrated in Fig. 3. This figure shows not two but three 'basins of attraction'. If the economy starts with a fairly equal division of each industry between the two countries, it will converge to a 'European' outcome without agglomeration; but if the industries are initially very unequally distributed, the concentrations are self-reinforcing and we end up with complete specialization.

The qualitative behaviour of this economy, then, depends on the level of

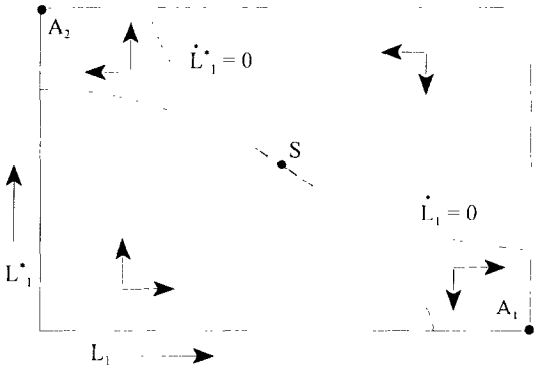

Fig. 2. Low τ.

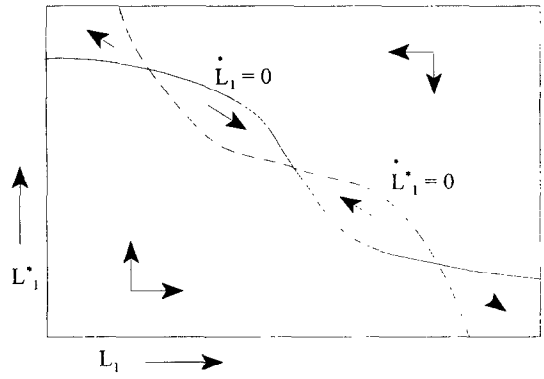

Fig. 3. Intermediate τ.

transport cost. At high levels of transport cost there is never agglomeration; there is a range of transport costs for which agglomeration may but need not occur; and at sufficiently low transport costs only agglomerated equilibria are stable. There are two critical levels of τ: $\bar{\tau}$, below which agglomeration can happen, and $\underline{\tau}$ below which it must happen.

We can derive analytical characterisations of both $\bar{\tau}$ and $\underline{\tau}$. Consider first $\bar{\tau}$. Suppose that each industry is concentrated in one country, e.g. $L_1 = 1$ and $L_1^* = 0$ as at A_1 on Fig. 2. This will be a locally stable outcome if $w_1 \geq w_2$ and $w_2^* \geq w_1^*$. Computing wages for this corner solution is much easier than in the general case, because many of the terms in the model drop out. In particular, setting $n_2 = n_1^* = 0$, $w_1 = w_2$, $w_1^* = w_2^*$ and requiring that all the above equations are satisfied gives the following restriction on parameters: [2]

$$\bar{\tau}^{\sigma(\mu-\nu)} = (1+\mu-\nu)\bar{\tau}^{1-\sigma} + (1+\nu-\mu)\bar{\tau}^{\sigma-1}. \tag{9}$$

The critical value of $\underline{\tau}$ – below which agglomeration must occur – can be found by finding the value of τ at which the symmetric equilibrium becomes unstable, i.e., at which the direction of intersection of the stationaries at S is reversed. The condition is [3]

$$\underline{\tau}^{\sigma-1} = \frac{[1+\mu-\nu][\sigma(1+\mu-\nu)-1]}{[1+\nu-\mu][\sigma(1+\nu-\mu)-1]}. \tag{10}$$

From these conditions it can be proved that, providing $\mu - \nu > 0$, the critical values of transport costs satisfy $\bar{\tau} > \underline{\tau} > 1$. The structure of equilibria illustrated in

[2] The condition is identical to that found in the Krugman (1991) model of factor mobility, except that the term $\mu - \nu$ (the difference between the share of own and other industry in costs) replaces the share of manufactures in the economy as a whole.

[3] Fuller details of the derivation of these critical values are available on request.

Table 2
Critical values of transport costs, $\bar{\tau}$ ($\underline{\tau}$)

σ	μ-ν		
	0.1	0.3	0.5
3	1.292 (1.286)	2.49 (2.21)	16.0 (4.58)
5	1.120 (1.119)	1.47 (1.42)	2.52 (1.90)
7	1.076 (1.075)	1.28 (1.25)	1.74 (1.50)

the figures is therefore quite general. Integration first makes agglomeration possible (Fig. 3) and then, if transport costs become low enough, make it necessary (Fig. 2). The condition $\mu - \nu > 0$ is crucial; it says that input–output links and the consequent cost and demand linkages are stronger within each of the industries than between them. If the condition is reversed each location will always have some of each industry, as firms derive more benefit from proximity to firms in the other industry than their own. [4]

Inspection of Eqs. (9) and (10) is not very illuminating about magnitudes of $\bar{\tau}$ and $\underline{\tau}$, or their dependence on parameters of the model. Table 2 reports values of $\bar{\tau}$ and $\underline{\tau}$ computed from these equations. As would be expected, the stronger are linkages (larger $\mu - \nu$) and greater the price–cost mark-up (smaller σ) the higher are the critical values, and therefore wider the range of transport costs within which agglomeration occurs.

4. The adjustment problem

Suppose that we take this model as a highly stylized representation of the reasons for the striking difference between the pattern of industry location between the US and Europe. That is, the geographic concentration of industry we consider to result from the historically higher degree of economic integration. What would we then expect to happen as Europe integrates?

One possibility is that in spite of integration, European trade costs remain substantially higher than those in the U.S. It is arguable that differences in language and culture will continue to segment markets, whatever the European Commission may do. In that case, of course, nothing will happen.

A second possibility is that while European markets become as integrated as those in North America, this increased integration is not sufficient to destabilize the existing geography of production. This case would correspond to the intermediate range of τ in Fig. 3, $\tau \epsilon (\underline{\tau}, \bar{\tau})$, in which there are multiple structural

[4] μ and ν both positive create forces for both industries to agglomerate in the same location – a possibility rule out here by full employment, but studied in Krugman and Venables (1995).

equilibria: markets are sufficiently well integrated that agglomeration is possible but not so integrated that it must happen. If a continent has developed highly geographically concentrated industries, they will persist; but a polycentric geography is also sustainable.

The third possibility is that the increased integration of European markets will, in fact, push the economy into the range in which existing national industries unravel, agglomerating into a smaller number of industrial districts serving the continent as a whole. The end result of this process will be to raise real incomes; in addition to the usual gains from integration, there are cost savings from the benefits of agglomeration. However, there may well be serious adjustment problems along the way. Each country will lose its presence in one of the industries, and workers in this industry will initially be hurt by integration and specialization. They will suffer a loss of real wages during the adjustment process and, in a more realistic model, we might well imagine that they will also experience a rise in unemployment adding to the painfulness of the adjustment.

The political difficulties posed by this adjustment problem are obvious. European nations may be enthusiastic about the benefits of economic integration in the abstract. But when it turns out that such integration involves losses as well as gains, and in particular that the geographic consolidation of industries means that some national industries vanish, the charges of 'social dumping' are sure to fly.

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