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# ABSTRACT

## Comparative Advantage and the Location of Production*

We return to a familiar topic in international trade, comparative advantage, introducing it into a model of economic geography. We provide a clear counterexample to the familiar result that trade liberalization leads to increased industrial concentration. Instead, lower trade costs may lead to a dispersion of production. As trade barriers diminish, agglomerative forces weaken, leaving room for other influences on the location of production. When a pattern of comparative advantage exists, integration may lead to international specialization of production. This may be good news for peripheral countries, which may be able to retain industry despite the attraction of the core.

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## NON-TECHNICAL SUMMARY

This paper blends two streams of research in international trade, one ‘new’ and the other ‘old’, in order to examine the location decisions of firms when there are technological differences between firms and between locations.

The aspect of the ‘new’ trade theory of particular concern to us has been named ‘new economic geography’ and seeks to explain how growing economic integration, in the form of diminished barriers to trade and factor migration, may result in the concentration of economic activity in one particular region or country, while others experience deindustrialization, as firms abandon their traditional production locations. The literature in economic geography typically downplays differences between firms and regions. Indeed, much of the research has investigated trade flows between essentially identical regions or countries, the trade arising from imperfectly competitive firms expanding their markets beyond national boundaries. In such a framework, industries are essentially footloose with nothing to tie them to any particular country.

This line of enquiry ignores those aspects of international trade that preoccupied analysts for many decades, where the trade occurs because countries differ from one another in terms of their technology or endowments of factors of production. Comparative advantage was the focus of ‘old’ international trade theory, with firms in an industry being attracted to a region or country because of the relative abundance of a particular factor of production or because the opportunity cost of producing that product was lower than in other locations because of differences in technology.

The aim of our paper is to investigate the pattern of trade and the location of production when there are fundamental differences in countries such that, following comparative advantage, firms have a preference as to the country in which they locate their production facilities but where, as in a model of economic geography, there are benefits to firms from congregating in a single location. We wish to determine the degree to which comparative advantage may impede industrial concentration resulting from falling trade barriers.

Our analysis is conducted in a world composed of two regions. Production is characterized by increasing returns to scale, creating an incentive for all production of a particular good to be concentrated in a single location. In addition, there are transport costs, raising the cost to consumers of goods imported from the foreign region. The cost of living will consequently be lower in the region with the greater level of production. Internationally mobile workers will be attracted to the region with the lower living costs. Firms will, in turn, find an advantage to locating closest to their larger market. These stimuli,

drawing workers and firms to locate in the same place, are known as agglomerative forces. In the absence of any countervailing pressures, we would expect all production to take place in a single location.

In this paper, we assume that the relative costs of producing various goods differ between regions. Thus the costs of producing a particular variety may differ between the two regions and different varieties will have different costs of production within each region. This disparity may arise from differences in technology, because the regions are at different stages of development, or may reflect the differences in regions' relative endowments of other factors of production. Whatever the explanation, this pattern of comparative advantage may mean that, as industry agglomerates, some firms will move from a relatively low-cost to a relatively high-cost production location.

Our model is similar in many respects to that of the seminal paper of Krugman (1991) but departs from it in one crucial respect. In Krugman's paper all of the varieties of manufactures are produced with the same technology, common to both regions. We introduce an element of comparative advantage, across varieties and between regions, which allows us to determine whether cost differences between regions may create an impediment to regional concentration of industry.

In Krugman's model, high trade costs lead to a diversified equilibrium where firms locate in both regions producing goods primarily for local consumption by manufacturing and agricultural workers. If trade costs fall sufficiently, strong agglomerative forces make possible equilibria where all manufacturing workers locate in one region, establishing a core-periphery pattern of production. As trade costs diminish, the core-periphery outcomes become the only stable equilibria and remain so, despite the diminishing strength of agglomerative forces, until trade is completely free (in which case, any spatial allocation of production is an equilibrium). For a small range of intermediate trade costs, the core-periphery model exhibits locally stable symmetric *and* agglomerated equilibria. In between these, on either side of the symmetric equilibrium, is an unstable asymmetric equilibrium.

The effect of trade liberalization is always to weaken the agglomerative forces and thus, when an element of comparative advantage is introduced, qualitatively different results from those of Krugman can be obtained. Thus, we show that when trade barriers are sufficiently low, comparative advantage can take the upper hand, pulling workers and production from the core to the other region. As impediments to trade continue to fall, the periphery expands until the diversified equilibrium is re-established. Intermediate trade costs lead to asymmetric equilibria but, contrary to the core-periphery model, these are stable. The stability properties of our model are thus a mirror image of the stability properties of the Krugman model.

The direct comparison of our results with those of Krugman might be considered a little misleading, as the two models differ in a significant aspect beyond our inclusion of comparative advantage. In Krugman's paper each region has a stock of internationally immobile agricultural workers, which ensures that, irrespective of the strength of agglomerative forces, neither region can ever be totally depopulated. We therefore investigate how including a similar agricultural sector in our model affects our results.

For high trade costs, trade is relatively unimportant and the need to supply local markets, in this case the agricultural workers, leads to dispersed production. As trade costs decline to an intermediate level, we show that agglomeration forces dominate. Low trade costs make location relatively unimportant and so any other force, such as comparative advantage, predominates. The inclusion of an agricultural sector does not change the fact that the small region (in this model) never empties out completely, since that would give an infinite comparative advantage to the small region. Instead we get a stable equilibrium close to full agglomeration.

Our model provides a clear counterexample to a central result of Krugman (1991), that trade liberalization tends to lead to more industrial concentration. We show instead that lower trade costs lead to a dispersion of production. Agglomeration forces (in the form of demand and supply linkages) weaken as trade costs are lowered and vanish completely in the limit where trade costs are eliminated. Comparative advantage acts as a dispersion force that is independent of trade costs. Therefore, as trade costs become less important, comparative advantage gradually becomes dominant, resulting in a dispersed equilibrium.

This result may be of some importance for regional policy. We have shown that economic integration, in the form of trade liberalization, may or may not lead to more concentrated production. As trade barriers fall, industrial location will become more dependent on comparative advantage. This might be good news for small countries in the integrating European market, which are located away from the central market, but have comparative advantages in some industries. Rather than being drained of their productive resources by an expanding core, these nations may be able to take advantage of the more liberal trade regime with a re-invigorated manufacturing sector.

## 1. Introduction

In the past few decades trade barriers have tumbled and national frontiers have become more porous as countries have admitted increasing levels of foreign direct investment and (particularly in the case of the European Union) immigration of workers. This growing economic integration has spurred studies on international trade and the location of economic activity, and this research has become commonly known as "economic geography". Much of this research has investigated trade flows between essentially identical regions or countries, the trade arising from imperfectly competitive firms expanding their markets beyond national boundaries. In such a framework, industries are essentially footloose with nothing to tie them to any particular country. In consequence, it is possible that further integration might lead to concentration of economic activity in one location, while other countries experience the flight of their national firms and deindustrialisation.

But this line of enquiry ignores trade arising from national differences (in technology, endowments, etc.). In this paper we reconsider comparative advantage, once the focus of international trade theory, and introduce it into a model of economic geography. The aim of our paper is to investigate the pattern of trade and the location of production when there are fundamental differences in countries such that, *ceteris paribus*, firms have a preference as to the country in which they locate their production facilities. We wish to determine the degree to which this may impede industrial concentration resulting from falling trade barriers.

We examine the spatial allocation of production activity in a world composed of two regions. Production is characterized by increasing returns to scale, creating an incentive for all production of a particular good to be concentrated in a single location. In addition, there are transport costs, raising the cost of consuming goods produced in the foreign region. The cost of living will consequently be lower in the region with the greater level of production. Internationally mobile workers will be attracted to the region with the lower living costs.

Firms will, in turn, find an advantage to locating closest to their larger market. These stimuli, drawing workers and firms to locate in the same place, are known as *agglomerative forces*.

In the absence of any countervailing pressures, we would expect all production to take place in a single location. Several possible sources of such countervailing pressures have been suggested in the literature. In Krugman (1991), there are internationally immobile agricultural workers who, when trade costs are sufficiently high, ensure sufficient local demand to support manufacturing in both locations. Ludema and Wooton (1997 and 1998) make manufacturing labour less-than-perfectly mobile, such that the wage premium offered has to rise in order to induce higher levels of migration. Helpman (1998) builds in congestion costs that reduce the amenity of increasing the concentration of workers.

In this paper, we assume that the relative costs of producing various goods differs between regions. This disparity may arise from differences in technology, because the regions are at different stages of development, or may reflect the differences in regions' relative endowments of other factors of production. Whatever the explanation, this pattern of comparative advantage may mean that, as industry agglomerates, some firms will move from a relatively low-cost to a relatively high-cost production location.

Our model is similar in many respects to that of Krugman (1991) but departs from that of Krugman in a crucial respect. In Krugman's paper, all of the varieties of manufactures are produced with the same technology, common to both regions. We introduce an element of comparative advantage across varieties and between regions. Thus the costs of producing a particular variety may differ between the two regions and different varieties will have different costs of production within each region. This innovation allows us to focus on the imperfectly competitive manufacturing sector, as the cost differences between regions may create an impediment to regional concentration of industry.

This means that we do not need to assume the existence of an immobile agricultural labour force in order to ensure that one of the regions does not become completely depopulated. In Section 2 we therefore model all productive activity as taking place in manufacturing, with internationally mobile workers. We do, however, in Section 3, make our model more closely resemble that of Krugman by introducing an agricultural sector that uses workers who are constrained to working in their own regions.

There is a small number of related papers that have recently been written. Amiti (1998) introduces cost differences into Venables' (1996) model of trade and location with vertically linked industries. She demonstrates that cost differences push firms to locate in different regions, while the demand and supply linkages make them agglomerate. The general conclusion of her paper is that firms will agglomerate for intermediate levels of trade costs. Amiti's analysis is conducted in partial equilibrium, with fixed factor prices, but her conclusions are nonetheless in accordance with those from the model in Section 4 of our paper.

Ricci (1997) also considers comparative advantage and economic geography. His model has two decreasing-cost industries, in addition to a constant-returns-to-scale sector. Each country has a comparative advantage in the production of one of these goods, but one country may have a "competitive advantage" (that is, higher average efficiency). He finds a tension between comparative advantage, which leads to international specialization of production, and agglomerative forces, which lead the larger country to expand production of both goods. We are able to demonstrate a result that Ricci is unable to rule out: that an increase in trade costs may enhance agglomeration.

In Venables (1998) analysis of comparative advantage and economic geography, he constructs a model that has multiple equilibria, including some in which industries are allocated between countries contrary to their comparative advantage. No such reversals occur in our model.

## 2. A Model of Geography and Trade

The world is composed of two regions, 1 and 2. Many varieties of a single good are produced and consumers, having a love of variety, will consume some of each variety sold in their region. These goods are produced in an imperfectly competitive environment, according to increasing returns to scale. There is free entry of firms, each of which produces a distinct variety of product. Goods can be traded between regions, but this trade is frequently costly, being subject to transport costs or trade taxes. Workers are internationally mobile, their migration leading to a equalization of the real wage across regions

Labour is the sole factor of production. Each region is endowed with an initial stock of workers, who may move freely within the manufacturing sector and may also migrate to work in the other region's manufacturing sector. Let $L_j$ be the number of workers employed in region *j* at a wage rate of $w_j$. The total number of workers is normalized to unity:

$$L_1 + L_2 = 1 \tag{1}$$

The manufacturing sector of region *j* produces $n_j$ varieties, this number being determined endogenously. Each variety of good is produced subject to a fixed cost and constant marginal cost. We assume that the marginal costs of production are the same for all varieties and for both regions, being equal to *b* units of labour. Fixed costs, however, are assumed to differ both within and across national manufacturing sectors. Let the labour requirement to produce $x_j$ units of output of variety *i* in region *j* be:

$$l_{ij} = a_{ij} + b\, x_j \tag{2}$$

where $a_{ij}$ is the fixed cost of producing variety *i* in region *j*. The cost function is then

$$c_{ij} = \left(a_{ij} + b\, x_j\right) w_j \tag{3}$$

We assume that the $a_{ij}$ can be ordered from lowest-cost to highest-cost variety in each region. Let the relationship between variety and number and the fixed cost of its production take the form:

$$a_{ij} = d\, i_j^{g}, \qquad g > 0 \tag{4}$$

The function is monotonic and may be concave ($g < 1$) or convex ($g > 1$).

We make the strong assumption that there is a comparative advantage in production between regions, in that the order of fixed costs in region 1 are exactly the reverse of that in region 2. We additionally assume that the range of possible varieties is sufficiently great that no two firms (anywhere) produce the same variety of good. These assumptions means that the variety that is most cheaply produced in region 1 would be the most expensive for a producer in region 2 to manufacture.[1]

All individuals share a utility function of the form:

$$U = C_M \tag{5}$$

where $C_M$ is the manufactures aggregate

$$C_M = \left( \sum_{j=1}^{2} \int_0^{n_j} c_{ij}^{\frac{s-1}{s}} \right)^{\frac{s}{s-1}} \tag{6}$$

$c_{ij}$ being the consumption of variety $i$ produced in region $j$ and $s > 1$ the elasticity of substitution between products.

### *2.1 The product market*

Each variety is produced by a single firm. Firms cannot discriminate between consumers in different regions and therefore charge a common (producer) price for their good. Trade between regions is costly. We assume these costs are of the "iceberg" type where $t > 1$ units must be shipped for one unit to arrive. The profit-maximising pricing behaviour of a representative firm in region $j$ is then equal to

$$p_j = \left( \frac{s}{s-1} \right) b\, w_j \tag{7}$$

[1] This is clearly a very strong assumption. However, it shows the consequences of introducing comparative advantage in production most clearly.

We chose units so that $b = (s - 1)/s$, which implies that $p_j = w_j$. From (7), it is clear that all varieties produced in a particular location will have the same price, irrespective of having different fixed costs. Given (6), consumers treat varieties symmetrically, wishing to consume identical quantities of varieties having the same price. Thus the output of every firm in region *j* will be the same $x_j$.

The profits of a firm are

$$p_{ij} = p_j x_j - c_{ij} \tag{8}$$

The profitability of firms will differ; those facing the lowest fixed costs generating the highest profits. We can think of these profits as being rents on some invisible fixed factor (which could be a physical factor or technical knowledge). By definition, those goods in which a region has the greatest comparative advantage will be the most profitable. Given the assumption of free entry into industry, new varieties will be added (at increasingly greater fixed cost) until the marginal firm $n_j$ makes zero profit. From (3) and (8), setting profits (8) equal to zero, the output of each firm will be

$$x_j = a_{nj} s \tag{9}$$

and, from (8) and (9), profits will be

$$p_{ij} = \left(a_{nj} - a_{ij}\right) w_j \tag{10}$$

Adding up the profits of all firms in region *j* yields

$$P_j = w_j \int_0^{n_j} \left(n_j a_{nj} - a_{ij}\right) di \tag{11}$$

The labour employed by each firm depends on the (common) level of output and the variety-specific fixed cost

$$l_{ij} = a_{ij} + b x_{ij} \tag{12}$$

Substituting (9), we get

$$l_{ij} = a_{ij} + a_{nj}(s - 1)$$

Integrating over all $n_j$ firms, we find total employment in manufacturing in region $j$

$$L_j = \int_0^{n_j} \left[ a_{ij} + n_j a_{nj} (s - 1) \right] di \tag{13}$$

Solving this integral and rearranging gives the number of firms in region $j$

$$n_j = \left[ \frac{L_j}{d_j \left( s - \frac{g}{1+g} \right)} \right]^{\frac{1}{1+g}} \tag{14}$$

Solving the integral (11) and using (14) we get total profit in region $j$

$$P_j = \frac{w_j L_j}{\left( \frac{1+g}{g} \right) s - 1} \tag{15}$$

The total income of each region is the sum of profits (15) and the wage bill

$$Y_j = \frac{w_j L_j}{1 - \frac{g}{s(1+g)}} \tag{16}$$

In equilibrium, the output of a particular firm must equal the demand for the variety that it is producing

$$\begin{aligned} p_1 x_1 &= \frac{p_1^{1-s} Y_1}{P_1^{1-s}} + \frac{(t p_1)^{1-s} Y_2}{P_2^{1-s}} \\ p_2 x_2 &= \frac{(t p_2)^{1-s} Y_1}{P_1^{1-s}} + \frac{p_2^{1-s} Y_2}{P_2^{1-s}} \end{aligned} \tag{17}$$

where the $P_1$ and $P_2$ are the price indices

$$\begin{aligned} P_1 &= \left[ n_1 p_1^{1-s} + n_2 (t p_2)^{1-s} \right]^{\frac{1}{1-s}} \\ P_2 &= \left[ n_1 (t p_1)^{1-s} + n_2 p_2^{1-s} \right]^{\frac{1}{1-s}} \end{aligned} \tag{18}$$

From (7), $w_1 / w_2 = p_1 / p_2$. Substituting this, (9), and (18) into (17) yields

$$\left(\frac{w_1}{w_2}\right)^s = \frac{a_{n2}}{a_{n1}} r \tag{19}$$

where $r \equiv \dfrac{n_1 w_1^{1-s} + n_2 (t w_2)^{1-s}}{n_1 (t w_1)^{1-s} + n_2 w_2^{1-s}}$.

If trade is free, $t = 1$. In that case $r = 1$ and (19) simplifies to

$$\frac{w_1}{w_2} = \left(\frac{a_{n2}}{a_{n1}}\right)^{\frac{1}{s}} \tag{20}$$

That is, the relative wage in region 1 will be the greater, the larger is the difference in the fixed cost of producing the marginal variety in region 2 compared to that in region 1. In a completely symmetric model, it is clear that wages in the two regions are only equalized when the same number of products are produced in the two regions and the number of workers in each region is the same.

### *2.2 The labour market*

We now consider the mobility of labour. Workers will seek to maximize their real return to labour, moving to the region with the higher real wage. A diversified equilibrium in the labour market (that is, both regions producing manufactured goods) will arise when

$$\frac{w_1}{P_1} = \frac{w_2}{P_2} \tag{21}$$

### *2.3 Equilibrium and stability*

It is no surprise that a symmetric allocation of production always is an equilibrium given the symmetry of the model. This can be verified, for instance, by taking $w_2$ as numeraire and substituting $w_1 = w_2 = 1$ in the model.

The next question concerns the stability of this equilibrium. With free trade, price indices are equal in the two regions, so the relative real wage depends on nominal wages. Substituting (13) into (19) gives

$$\frac{w_1}{w_2} = \left( \frac{L_2}{L_1} \right)^{\frac{g\, s}{1+g}} \tag{22}$$

Moving one unit of labour from region 2 to region 1 will, from (22), decrease the relative nominal wage in region 1. Labour will therefore choose to relocate back to region 2, and the symmetric equilibrium is stable. The intuition for this result is that agglomeration forces, in form of demand linkages and supply linkages, cease to operate when trade is free. Location of production is governed by comparative advantage and, since comparative advantage is symmetric in this model, the symmetric equilibrium is stable.

When $t > 1$ it is difficult to solve the model analytically. It is, however, possible to linearize the model around the symmetric steady state to check local stability. In standard terminology, we wish to find the "breakpoint". Similarly, is it possible to find the level of trade costs for which complete agglomeration is broken, determining the "sustain point". We will start with the former. Define

$$R \equiv \frac{w_1 P_2}{w_2 P_1}; \quad PP \equiv \frac{P_1}{P_2}; \quad W \equiv \frac{w_1}{w_2}; \quad A \equiv \frac{L_1}{L_2}$$

Note that, in the symmetric steady state, $PP = W = A = 1$. Local stability is determined by the sign of $¶R / ¶A$. For instance, a positive sign implies that the relative real wage in a region increases as the relative population increases. In this case even more labour is drawn to a larger region, which implies that the symmetric equilibrium is unstable. Differentiating the relative real wage gives

$$dR = dW - dPP \tag{23}$$

Using (13) and (17) the relative price level can be expressed according to

$$PP = \left( \frac{A^{\frac{1}{1+g}} W^{1-s} + f}{f A^{\frac{1}{1+g}} W^{1-s} + 1} \right)^{\frac{1}{1-s}} \tag{24}$$

where $f = t^{1-s}$ stands for "freeness" of trade and $f$ ranges between 0 (infinite trade costs) and 1 (free trade). Differentiating (24) gives

$$dPP = \frac{1-f}{(1+g)(1-s)(1+f)}dA + \frac{1-f}{1+f}dW \tag{25}$$

Using (15), (16), and the fact that $Y_j = n_j p_j x_j$ in equilibrium, (25) can be rearranged according to

$$1 = \frac{1}{1 + A^{-\frac{1}{1+g}} f W^{s-1}} + \frac{f W^{-1} A^{-1}}{f + A^{-\frac{1}{1+g}} W^{s-1}} \tag{26}$$

Differentiating (26) and rearranging gives

$$0 = \frac{2f}{(1+f)^2}\left(\frac{dA}{1+g} - (s-1)dW\right) - \frac{f}{1+f}dW - \frac{f}{1+f}dA \tag{27}$$

(23), (25), and (27) can now be used to form

$$\frac{dR}{dA} = \frac{2fg(1-s) + (1-f)(2s-1)}{(1+g)(2s-1+f)(s-1)} \tag{28}$$

Clearly the denominator is always positive, since $s > 1$ and $0 < f < 1$. The sign of the numerator therefore determines the stability of the symmetric equilibrium. For free trade ($f = 1$), $dR/dA<0$ implying that the symmetric equilibrium is stable. None of the usual agglomerative forces (demand and supply linkages) are at work when there are no trade costs. Comparative advantage will therefore, alone, dictate the most efficient allocation of production. In this model, production costs are increasing symmetrically with size in both regions. Symmetric allocation of production is therefore stable in the long-run equilibrium. For prohibitive trade costs ($f = 0$), comparative advantage ceases to matter, since there is no trade. Consequently agglomeration forces will dominate, and the symmetric equilibrium is unstable.

The effect of stronger comparative advantage (higher $g$) is also clear from (28). A higher $g$ boosts the negative term in the numerator, which implies that it has a stabilising effect on the symmetric equilibrium. The effect of $f$ can also be seen from the numerator of (28). A higher $f$ (lower trade costs) will increase the negative term and decrease the positive term thereby stabilising the symmetric equilibrium. The critical $f$, below which the symmetric equilibrium ceases to be stable, is given by

$$f^{crit} = \frac{2s - 1}{2s - 1 + 2g(s - 1)} \tag{29}$$

For example, a stable symmetric equilibrium implies that $t < 1.66$ for $s = 2$ and $g = 1$ while $t < 1.22$ for $s = 4$ and $g = 1$.

Next we derive the critical value of $f$ to sustain complete agglomeration. Assume that all production and all labour is agglomerated in region 1, and take the nominal wage in this region as numeraire, $w_1 = 1$. Now move one unit of labour to region 2, let firms enter and exit, and compare the real wage in the two regions. Complete agglomeration will not be sustainable if the real wage in region 2 is higher than in region 1. From (17) the price indices are given by

$$P_1 = n_1^{\frac{1}{1-s}}, \quad P_2 = t\, n_1^{\frac{1}{1-s}} \tag{30}$$

Therefore the agglomerated equilibrium ceases to be stable when $w_2 > t$. $w_2$ has yet to be determined. Using the fact that $p_j = w_j$ and $p_1 x_1 n_1 = Y_1$, then (8), (16) and (30) gives

$$w_2 = f^{\frac{1}{s}} \left( \frac{n_1}{n_2} \right)^{\frac{g}{s}} \tag{31}$$

This expression reveals that complete agglomeration never occurs, since $n_1/n_2$ becomes arbitrarily large for a marginal amount of labour in region 2. Essentially a small region has an infinite comparative advantage. Consequently we get a stable equilibrium close to full agglomeration for high trade costs. Figure 1 shows the qualitative structure of equilibria.

**{Figure 1 about here}**

While the analysis so far explores the long-run stability properties of the model locally, we must turn to numerical simulations to fully explore the model.

### *2.4 Simulation Results*

In Krugman's (1991) core-periphery model, high trade costs lead to a diversified equilibrium where firms locate in both regions producing goods primarily for local consumption by manufacturing and agricultural workers. If trade costs fall sufficiently, strong agglomerative forces make possible equilibria where all manufacturing workers locate in one region, establishing a core-periphery pattern of production. As trade costs diminish, the core-periphery outcomes become the only stable equilibria and remain so, despite the diminishing strength of agglomerative forces, until trade is completely free (in which case, any spatial allocation of production is an equilibrium). Finally, for a small range of intermediate trade costs, the core-periphery model exhibits locally stable symmetric and agglomerated equilibria. In between these, on either side of the symmetric equilibrium, there is an unstable asymmetric equilibrium.

Now contrast these results with those of our model. The effect of trade liberalization is to weaken the agglomerative forces. Consequently, in our model and when trade barriers are sufficiently low, comparative advantage takes the upper hand, pulling workers and production from the core to the other region. As impediments to trade continue to fall, the periphery expands until the diversified equilibrium is re-established. Intermediate trade costs lead to asymmetric equilibria but, contrary to the core-periphery model, these are stable. The stability properties of our model are thus a mirror image of the stability properties of the Krugman model.

**{Figure 2 about here}**

We illustrate the simulation results when the fixed costs are linear, but qualitatively similar pictures will emerge for a variety of $g$'s. The simulations in Figure 1 largely confirm the results from the analytical section. For low trade costs, comparative advantage will dominate the location of production activities, while higher trade costs make demand and supply linkages more important, leading to a stable core-periphery outcome in the long-run. For intermediate trade costs, we get stable intermediate equilibria, while both complete agglomeration and the symmetric equilibrium are unstable.

One important question is why this model, contrary to Krugman (1991), produces *stable* asymmetric equilibria. The reason is that in our model comparative advantage-the force leading to dispersion-becomes stronger the more asymmetric the distribution of production. Indeed in the limit these forces become infinite. Agglomeration forces on the other hand are constant. That is, a given relocation of workers gives rise to a given change in the number of firms in both regions since the firm size is constant. This yields a constant effect on the price index (which determines demand and supply linkages), since the elasticity of the price index with respect to $n$ is constant.

## 3. The Dual Economy

The direct comparison of our results with those of Krugman has been somewhat misleading, as the two models differ in a significant aspect beyond our inclusion of comparative advantage. In Krugman (1991) each region has a stock of internationally immobile agricultural workers which ensures that, irrespective of the strength of agglomerative forces, neither region can ever be totally depopulated. We now investigate how including a similar agricultural sector in our model will affect our results.

Suppose now that, as in Krugman (1991), each region has a fixed stock of workers employed in producing an agricultural good. The agricultural product is homogeneous with identical production technology in the two regions. These workers are both intersectorally immobile (they cannot move into manufacturing employment) and internationally immobile. The good that they produce is, however, freely traded between the nations. Our (re)introduction of the agricultural good to the model permits a more direct comparison of our results with those of the previous literature on economic geography.

The general intuition is that, for low trade costs, agglomeration forces are weak. Therefore any dispersion force that is independent of trade costs, such as comparative advantage, will dominate. For intermediate trade costs agglomeration forces become stronger and we tend to get agglomerated equilibria. For high trade costs in manufacturing, however, trade becomes relatively unimportant for this sector. Location will therefore be determined primarily by local demand. The agricultural worker provides such a geographically immobile local demand. Consequently, this change in the model introduces the possibility of stable, symmetric equilibria for high trade costs.

We have to amend several of the equations in the preceding section of this paper in order to incorporate consumption of the agricultural good and the incomes paid to workers for its production.[2] The total population of the world is unity, but we assume that there are $(1-m)/2$ agricultural workers in each region. Consequently, the population of workers in manufacturing is now

$$L_1 + L_2 = m \tag{32}$$

The utility function (5) becomes

$$U = C_M{}^m C_A^{1-m} \tag{5'}$$

Agricultural income is the numeraire and so the income of each region is

$$Y_j = \frac{1-m}{2} + P_j + w_j L_j \tag{33}$$

This model cannot be solved analytically. It is, however, again possible to linearize the system around the symmetric steady state to find the break-point; that is the level of trade costs at which the symmetric allocation becomes unstable.

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[2] In order to facilitate comparison of results, we follow Krugman (1991) as closely as possible.

Using the expression for $P$ in (15) gives:

$$Y_j = \frac{1-m}{2} + \frac{w_j l m}{h} \tag{34}$$

where $l = L_1/(L_1+L_2)$ and $h = 1 - 1/(s + s/g)$. Differentiating (34) and evaluating the expression at the symmetric steady-state gives:

$$dY = \frac{m dw}{2h} + \frac{m d l}{h} \tag{35}$$

Differentiation of the price level gives (after some manipulation):

$$\frac{dP}{P} = Z\left(\frac{2 d l}{(1-s)(1+g)} + dw\right) \tag{36}$$

where $Z \equiv (1-f)/(1+f)$ represents trade costs and lies in the interval [0,1]. Using the CES demand functions in (17) and evaluating the total differential at the symmetric steady state gives, after simplification:

$$dw = \frac{1}{s}\left[\frac{2Z}{s}\left(s - \frac{g}{1+g}\right)\left(dY + \frac{s-1}{2}\frac{dP}{P}\right) - \frac{g}{1+g} d l\right] \tag{37}$$

Finally, differentiating the real wage yields:

$$dw = \left(dw - m\frac{dP}{P}\right)P^{-m} \tag{38}$$

The sign of $dw/d l$ determines the stability of the symmetric equilibrium. A positive derivative implies that moving labour to region 1 increases the real wage in this region and (by symmetry) decreases the real wage in region 2. The symmetric equilibrium is in this case unstable. The same logic, *mutatis mutandis*, carries through for a negative derivative. Using (35), (36), (37), and (38) we get $dw/d l$ as a rather complicated function of the parameters of the model:

$$\frac{dw}{d l} = \frac{\left[\begin{array}{l} 2Z^2\left(m^2 g^2 s(s-1) + gs(s-2) + m^2 s^2(1+2g) - m^2 sg + g + s(s-1)\right) \\ + smZ\left(-3sg^2 + 3g^2 - 7sg - 4s + 5g + 2\right) - sg((1-s)(1+g)) \end{array}\right]}{P^m(1+g)(1-s)\left[Z^2\left(s^2 g - 2sg + g + s(s-1)\right) + smZ(1+g) - s^2(1+g)\right]} \tag{39}$$

It can easily be verified that for $g = 0$ this expression simplifies to the corresponding expression for the core-periphery model.[3] It should be noted that trade costs enter (39) in a quadratic fashion, which indicates the possibility of two break points.

Figure 3 plots (39) for standard parameter values.

**{Figure 3 about here}**

Figure 3 shows that the symmetric equilibrium tends to be stable for low and high trade costs, while it tends to be unstable for intermediate trade costs. If comparative advantage, which is a force of dispersion in our model, is sufficiently strong e then the symmetric equilibrium is stable irrespectively of trade costs. Higher *m* or *s* lift the bell-shaped curve, thereby decreasing the range of trade costs for which the symmetric equilibrium is stable.

Figure 3 shows a pattern that is fairly general in the literature on trade and location.[4] Agglomeration forces dominate for intermediate trade costs. For low trade costs location becomes relatively unimportant, so any other force that does not depend on trade costs will tend to dominate. In our model this force is comparative advantage. For high trade costs, finally, trade becomes less important and the need to supply local markets, here the agricultural sector, will lead to dispersed production.

Finally, the introduction of an agricultural sector does not change the fact that the small region in this model never empties out completely, since that would give an infinite comparative advantage to the small region. Instead we get a stable equilibrium close to full agglomeration.

**{Figure 4 about here}**

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[3] See Fujita, Krugman and Venables (1998) for the corresponding expression for the core-periphery model.

[4] See Ottaviano and Puga (1997).

The model is simulated in Figure 4, which shows the relative real wage in the two regions as the relative labour stock is changed. Figure 4 corresponds to Figure 2 in the dual case. The simulations confirm that the symmetric equilibrium is stable for intermediate trade costs but unstable for high or low trade costs. Note also that the manufacturing sector never completely disappears in the small region. Finally, Figure 5 shows quantitatively the structure of equilibria.

**{Figure 5 about here}**

## 4. Conclusions

We have investigated the consequences of introducing a form of comparative advantage into a model of economic geography. Our analysis was conducted in two steps. Firstly we considered the effects of this comparative advantage when all factors are internationally mobile. We then analysed the implications of incorporating comparative advantage in a model that is otherwise the same as that of Krugman (1991).

Our model provides a clear counter example to a central result of Krugman (1991), that trade liberalization tends to lead to more industrial concentration. We show instead that lower trade costs lead to a dispersion of production. Agglomeration forces (in the form of demand and supply linkages) weaken as trade costs are lowered and vanish completely in the limit where trade costs are eliminated. We have introduced a dispersion force (comparative advantage) that is independent of trade costs. Therefore, as trade costs become less important, comparative advantage gradually becomes dominant resulting in a dispersed equilibrium.

This may be important for regional policy. We have shown that economic integration, in the form of trade liberalization, may or may not lead to more concentrated production. As trade barriers fall, industrial location will become more dependent on comparative advantage.

This might be good news for small countries in the integrating European market, which are located away from the central market, but have comparative advantages in some industries. Rather than being drained of their productive resources by an expanding core, these nations may be able to take advantage of the more liberal trade regime with a re-invigorated manufacturing sector.

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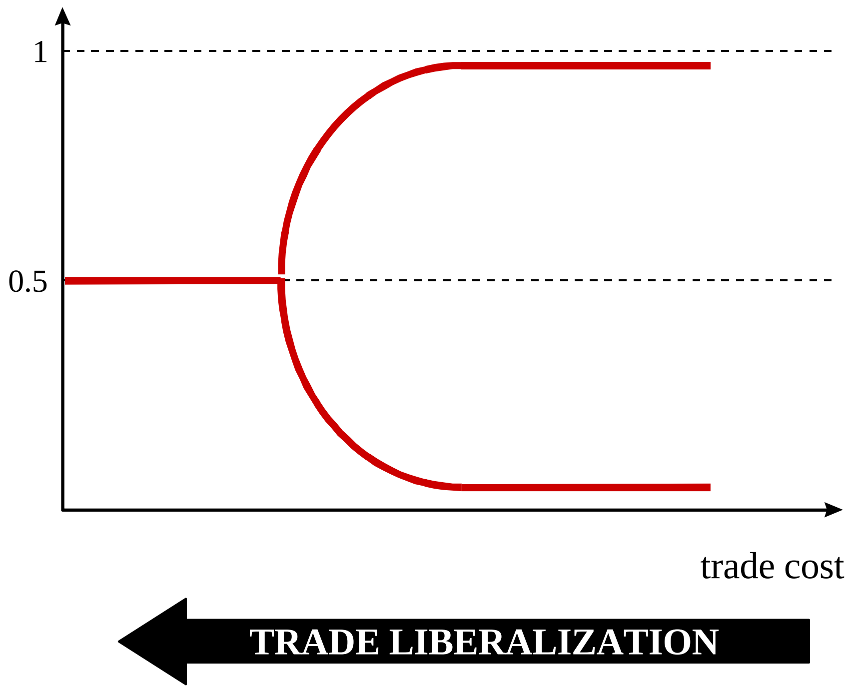
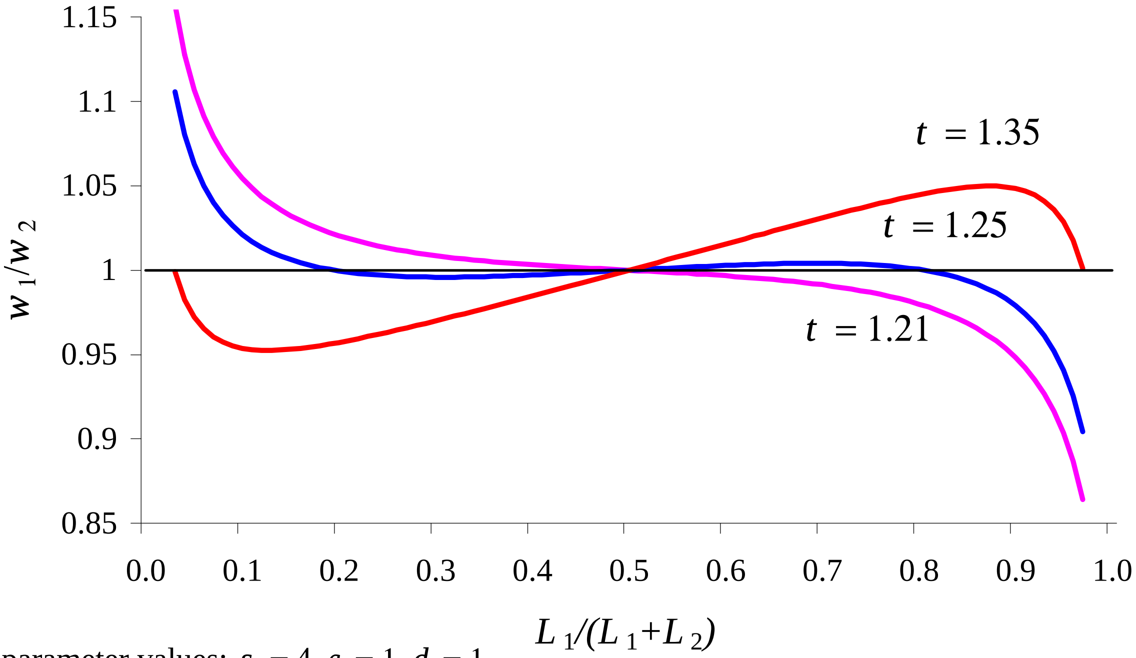
Figure 1 Manufacturing Sector Only

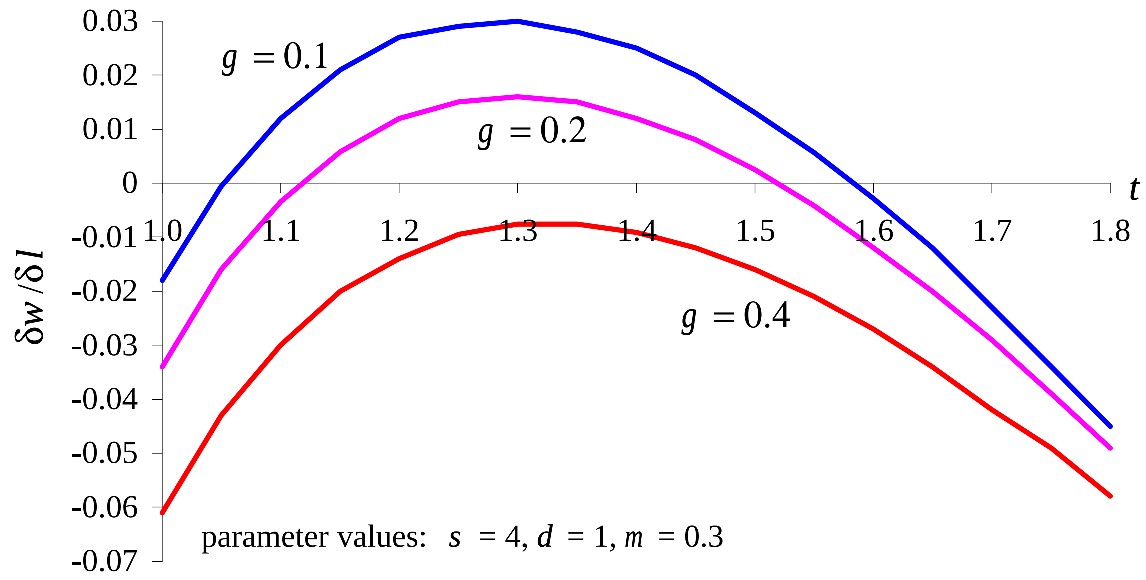



# Figure 2

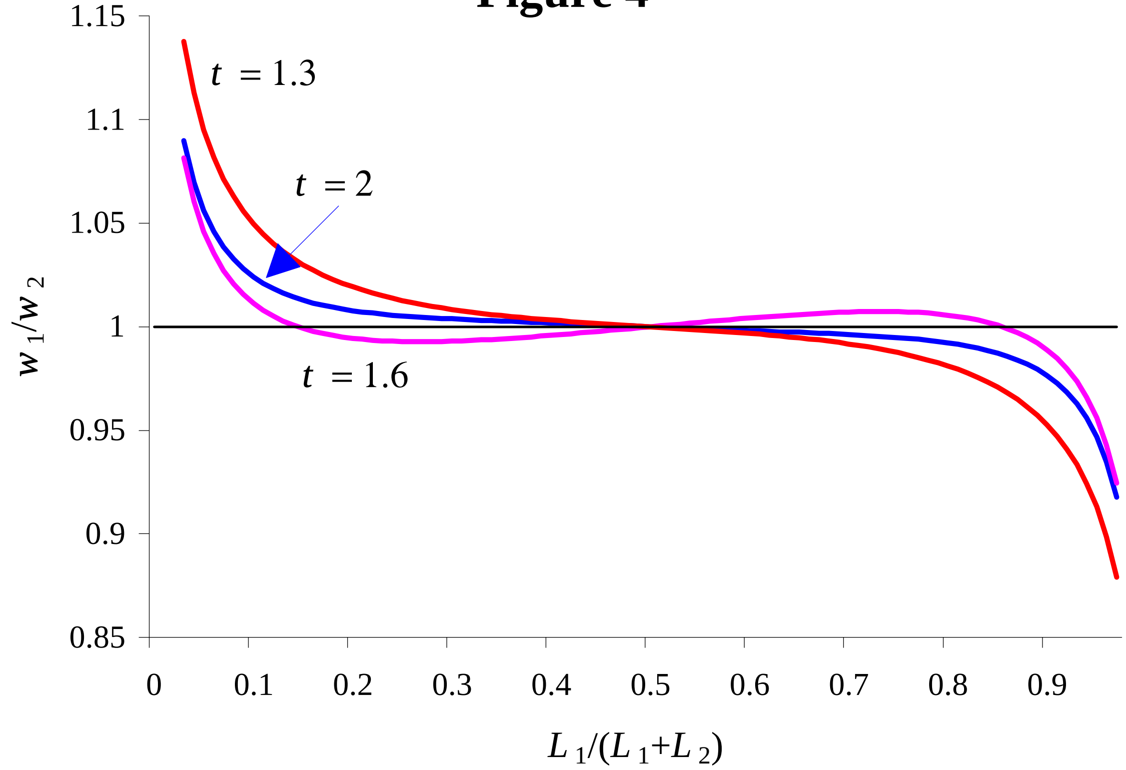



parameter values: $s = 4$, $g = 1$, $d = 1$

## Figure 3




## Figure 4




parameter values: $s$ = 5, $g$ = 1, $d$ = 1, $m$ = 0.7, $L$ = 10, $L_z$ = 5

Figure 5  Manufacturing and Agricultural Sectors