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Comparative advantage And The Location of Production*

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Abstract

We return to a familiar topic in international trade, comparative advantage, introducing it into Krugman's classic, core-periphery model of economic geography. This extra force of dispersion radically changes the stability properties of the model. Instead of the familiar result that trade liberalization leads to increased industrial concentration, lowering trade costs leads initially to increased concentration and then to dispersion 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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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, adding to the burgeoning literature in “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 deeper integration might lead to economic activity becoming concentrated in a single location, with the other countries experiencing the flight of their national firms and deindustrialization.

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. Our goal is to determine the degree to which such preferences may impede the industrial concentration that would otherwise ensue 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 it advantageous to set up close 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 production of all goods to take place in a single location. Several possible sources of such countervailing pressures have been suggested in the literature. In Krugman (1991a), 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 2000) 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 differ 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 the 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.[1]

We have chosen to construct a framework that is a variant of Krugman’s (1991a) core-periphery model, the seminal work in economic geography. As this framework is by now well understood, the implications of introducing comparative advantage stand out clearly. Of necessity, we have to depart from the Krugman model in some crucial respects. In Krugman’s paper, all 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. These cost differences between regions may create an impediment to the concentration of industry in a single location. We therefore do not need

Krugman's assumption of an immobile agricultural labour force to ensure that neither region becomes completely depopulated.

Our work joins a small number of related, but distinctly different, papers that have recently been written on geography and comparative advantage. 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 nonetheless agree with those in Section 3 of this paper. Venables (1999) also analyses some aspects of comparative advantage and economic geography using a model of vertically linked industries. He constructs a model that has multiple equilibria, including some in which industries are allocated between countries contrary to their comparative advantage. Finally, Ricci (1999) constructs a model that 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. However, contrary to our study, Ricci does not analyse the effects of economic integration on agglomeration when factor mobility is allowed.

Our analysis differs from the mentioned studies in several ways. Crucially, while the cited papers use versions of the vertical model by Venables (1996), we take as our point of departure the core-periphery model of Krugman (1991), and make a minimal variation of this standard model. This makes our model considerably less complex. Because of the close relationship of our framework to that of the core-periphery model, our results are more readily comparable to the existing literature.

In Section 2 we assume that all productive activity takes place in manufacturing, with internationally mobile workers, and in the absence of an agricultural sector. This model behaves as a mirror image of Krugman's model, in that there is concentration for high trade costs and dispersed production for low trade costs. Thus introducing comparative advantage and excluding factor immobility gives results starkly different from those of Krugman.

In Section 3, we make the model more closely resemble that of Krugman by introducing an agricultural sector that uses workers who are constrained to working in their own regions, while we retain the assumption of comparative advantage in manufacturing. The model now displays diversification for high trade costs, agglomeration for intermediate trade costs, and (in contrast to Krugman) dispersion once again for low trade costs. As similar outcomes are derived in the different settings of Krugman and Venables (1995) and Puga (1999), our findings support the general result that agglomeration tendencies are non-monotone in trade costs, with a maximal tendency for concentration for intermediate trade costs.

2. A Model of Geography and Trade

We start with a model that differs from Krugman (1991a) in two respects: there is no production of agricultural goods while manufacturing is characterised by international comparative advantage.

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 every 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 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 (traded) 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. This can be motivated by assuming the presence of a non-traded factor of production only used in the fixed-cost component of production. This factor could be, say, land or skilled capital. In any event, the factor supply is of variable quality. Owners of the most productive land, or managers with the highest skills, will combine with a small number of workers in order to create the necessary fixed input. Owners of less productive non-traded factors will need more workers and will consequently face higher fixed costs of production. Let the labour requirement to produce x_j units 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 i 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 ($g > 1$).

Comparative advantage in production between regions arises from the fact that no firm in either region would choose to manufacture a variety that is identical to that of any other firm.[2]

Consequently, each country will have a range of varieties in which its fixed costs are lower than in the other location, giving each nation a comparative advantage over a range of manufacturing production.[3]

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

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

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.[4] 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 a firm *i* will be

$$x_{ij} = a_{nj} s \tag{9}$$

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

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

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

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

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

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

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

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

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

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

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

$$Y_j = \frac{w_j L_j}{1 - g / \left[s(1+g)\right]} \tag{16}$$

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 $r \equiv \dfrac{P_2^{1-s} Y_1 + P_1^{1-s} f Y_2}{P_2^{1-s} f Y_1 + P_1^{1-s} Y_2}$.

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, and we will impose the following law of motion:

$$\frac{\dot{s}_L}{s_L} = (-s_L)\, W[s_L] \tag{21}$$

where s_L is the share of workers in region 1, $s_L \equiv L_1/(L_1 + L_2)$, and $W \equiv w_1/P_1 - w_2/P_2$. This migration rule is optimal with static expectations and quadratic adjustment costs (see Ottaviano, 1996, and Baldwin, 1999). A diversified equilibrium in the labour market (that is, both regions producing manufactured goods) will arise when $w_1/P_1 = w_2/P_2$.

2.3 Equilibrium and stability

It is no surprise that a symmetric allocation of production is always 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 (14) into (20) 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 the agglomerative forces 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.

Finding an analytical solution to this type of model is difficult whenever there are trade barriers (that is, when $t > 1$). It is, however, possible to linearize the model around the symmetric steady state to check local stability. Similarly, is it possible to find the level of trade costs for which complete agglomeration is broken. In what has become standard terminology, we wish to find the "breakpoint"; i.e. the level of trade costs below which the symmetric equilibrium ceases to be stable. Similarly, is it possible to find the level of trade costs above which complete agglomeration is broken, determining the "sustain point". We will start with the breakpoint. 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, $Q = W = A = 1$. Local stability is determined by the sign of $\partial R / \partial A$. For instance, a positive sign implies that the relative real wage in a region increases as the share of population rises. Consequently, even more workers are drawn to the larger region, indicating that the symmetric equilibrium is unstable. Differentiating the relative real wage gives

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

Using (14) and (18) the relative price level can be expressed according to

$$Q = \left[\frac{A^{\frac{1}{1+g}} W^{1-s} + f}{f A^{\frac{1}{1+g}} W^{1-s} + 1} \right]^{\frac{1}{1-s}} \tag{24}$$

where $f \equiv t^{1-s}$ measures the "freeness" of trade, f ranging between 0 (infinite trade costs) and 1 (free trade). Totally differentiating (24) gives

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

Using (16), (17), 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

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

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

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

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, $dR/dA < 0$, confirming that the symmetric equilibrium is stable in the long-run equilibrium. For prohibitive trade costs ($f = 0$), comparative advantage ceases to matter, since there is no trade. Consequently agglomerative 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

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

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, that is, $w_1 = 1$. 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 (18) the price indices are given by

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

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 (9), (17), and (30) give

$$w_2 = f^{\frac{1}{s}} \left(\frac{a_{n1}}{a_{n2}} \right)^{\frac{1}{s}} \qquad (31)$$

This expression reveals that complete agglomeration never occurs, since a_{n1}/a_{n2} becomes arbitrarily large for a marginal amount of labour in region 2. Essentially the first marginal firm in a small region has an infinite comparative advantage, since it has a zero fixed cost. As long as trade costs are not infinite this marginal firm will sell at least the quantity epsilon, which is enough to generate a positive profit with zero fixed cost and a positive mark-up. Consequently we get a stable equilibrium close to full agglomeration (s_L close to zero or one) for high trade costs t. Figure 1 shows the qualitative structure of equilibria, where a solid line depicts stable equilibria.

INSERT Figure 1 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 (1991a) 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. Lower trade costs diminish agglomerative forces as well as the dispersion force due to market crowding. However, the dispersion force falls at a faster rate than the agglomeration forces. Therefore sufficiently low trade costs make possible equilibria where all manufacturing workers locate in one region, establishing a core-periphery pattern of production. Thus there is a range of (intermediate) trade costs over which the model exhibits both a locally stable symmetric equilibrium and two locally stable agglomerated equilibria, as well as two unstable asymmetric equilibria. But, as trade costs further diminish, the core-periphery outcomes become the only stable equilibria. They 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).

The effect of trade liberalization is to weaken the agglomerative forces in our model, while comparative advantages are unaffected. Therefore, 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.

INSERT Figure 2 here

We illustrate the simulation results when the fixed costs are linear in i (γ=1), but qualitatively similar pictures will emerge for a variety of values of g. The simulations in Figure 2 largely confirm the results from the analytical section.[5] 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 (1991a), 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. Agglomerative 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 the strength of the agglomerative forces), since the elasticity of the price index with respect to n is constant.

3. The Dual Economy

Our model and that of Krugman (1991a) share the same mechanism for agglomeration, but the offsetting forces of diversification are completely different. We have introduced comparative advantage in the manufacturing sector while Krugman incorporates an agricultural sector in his model. We now investigate how including a similar agricultural sector in our model will affect our results, leaving comparative advantage as our only addition to Krugman's model.

Suppose now that, as in Krugman (1991a), 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, agglomerative forces are weak. Therefore any dispersion force that is independent of trade costs, such as comparative advantage, will dominate. For intermediate trade costs agglomerative forces become stronger and we tend to find agglomerated equilibria. With 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 because, irrespective of the strength of agglomerative forces, neither region can ever be totally depopulated.

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.[6] 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 breakpoint; that is the level of trade costs at which the symmetric allocation becomes unstable.

Using the expression for P in (15) gives:

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

where $l \equiv L_1/(L_1+L_2)$ and $h \equiv 1-1/(s + s/g)$. 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):

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

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:

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

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:

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

It can easily be verified that for $g = 0$ this expression simplifies to the corresponding expression for the core-periphery model:[7]

$$\frac{dw}{d\,l} = \frac{2P^{-m}Z\left\{Z\left[s\left(1+m^2\right)-1\right] + m(1-2s)\right\}}{(s-1)\left[s - mZ - Z^2(s-1)\right]} \quad \text{for} \quad g = 0$$

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.

INSERT Figure 3 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 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 (Ottaviano and Puga, 1997). Agglomerative 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.

INSERT Figure 4 here

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 for 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.

INSERT Figure 5 here

An important feature of the model, shown in Figure 5, is the somewhat gradual change of stable equilibria from complete agglomeration to a symmetric allocation of labour as trade costs are lowered.[8]

4. Conclusions

Much of the recent research activity in international trade theory has focussed on explaining the influences on regional location and industrial concentration. The models' focus on agglomeration forces has often resulted in an exclusion of the traditional bases for trade between countries. We have examined the role played by a traditional basis for trade within a new economic geography framework by investigating the consequences of introducing comparative advantage into an economic geography model.

We chose to adapt Krugman's (1991a) now-classic, core-periphery model of economic geography. Our analysis was conducted in two stages. As a first step we considered the effects of this comparative advantage in a one-sector model with internationally mobile workers in order to examine the relationship between trade liberalisation and location of economic activity. We then moved closer to Krugman by (re)introducing the agricultural sector. The resulting model is the same as that of Krugman in all respects other than the presence of comparative advantage.

Our first experiment provides a clear counterexample to a central result of Krugman (1991a), that trade liberalization tends to lead to more industrial concentration. We show instead that lower trade costs lead to a dispersion of production. Agglomerative forces 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.

In our second experiment, where an agricultural sector with geographically immobile has been added, our model displays dispersion for high trade costs, agglomeration for intermediate trade costs, and once again dispersion as trade costs become even lower. This return to dispersion does not arise in Krugman, where the core-periphery outcomes are the only stable equilibria until free trade is established. Similar production and trade patterns may be found in different settings in other new economic geography models (Fuijita, Krugman, and Venables, 1999, chapter 14). Our analysis underscores the generality of these outcomes.

Our results may be of some consequence 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.

5. References

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Endnotes

[1] Comparative advantage will always work against all activities being concentrated in one region. In our set-up regions have comparative advantage within the manufacturing sector, which implies that it is a force against industrial concentration in the manufacturing sector. However, in a set-up where (for instance) one region has a comparative advantage in manufacturing and the other region

in agriculture, comparative advantage will be a force that strengthens the tendencies for all manufacturing to agglomerate in one region, while the other region will specialise in agriculture.

[2] While it might appear better for the marginal firm to compete in the market for a variety in which the incumbent firm is making profits, rather than producing a new variety generating zero profits, this is not the best strategy as the marginal firm does not have access to the lower fixed costs facing the incumbent.

[3] These assumptions about the nature of the production technology and the pattern of comparative advantage are clearly very strong. We introduce comparative advantage only in the fixed cost for analytical convenience. The assumption implies that all varieties are priced with a constant mark-up, and that we have identical demand for each variety. If, instead, comparative advantage entered via variations in total costs or the variable cost, mark-up, price and sales would vary among firms. This would greatly complicate the analysis. Our conjecture is, however, that these alternative specifications would lead to very similar results. The reason for this is that as long as comparative advantage is an exogenous force, it will necessarily dominate for low trade costs when all other locational forces become irrelevant. Likewise, as long as the exogenous comparative advantage forces are not too strong, agglomeration forces will dominate for some range of trade costs.

[4] We can think of these profits as being rents on the non-traded input (land or technical knowledge on the part of the firm's owner).

[5] The model in section 2 is numerically simulated using the non-linear equation system solver in Matlab 4.2.

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

[7] This corresponds to equation (5A.5) in Fujita, Krugman and Venables (1999).

[8] Puga (1999) obtains a similar result by letting the expanding industry draw from a regional labour pool. This creates a force of gradual resistance to agglomeration, which produces a smooth transition between the symmetric and the agglomerated equilibrium.

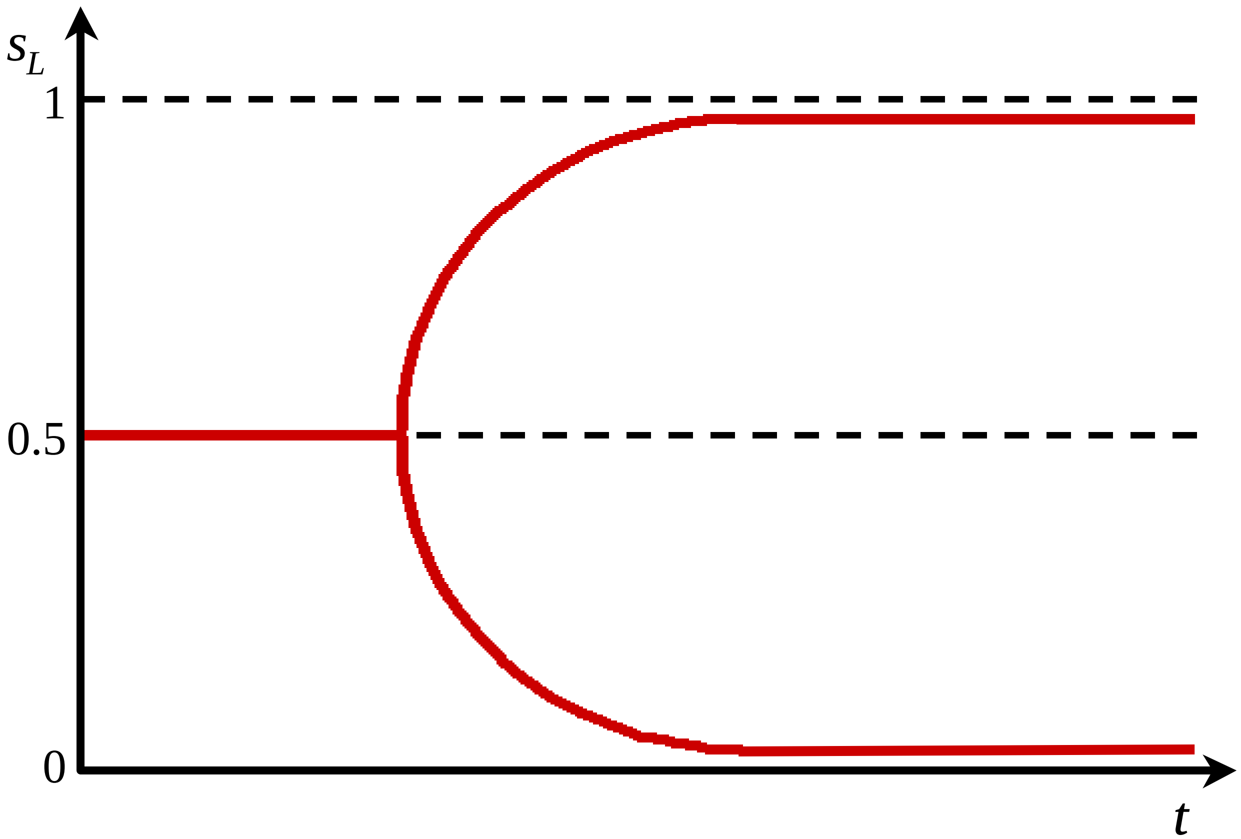
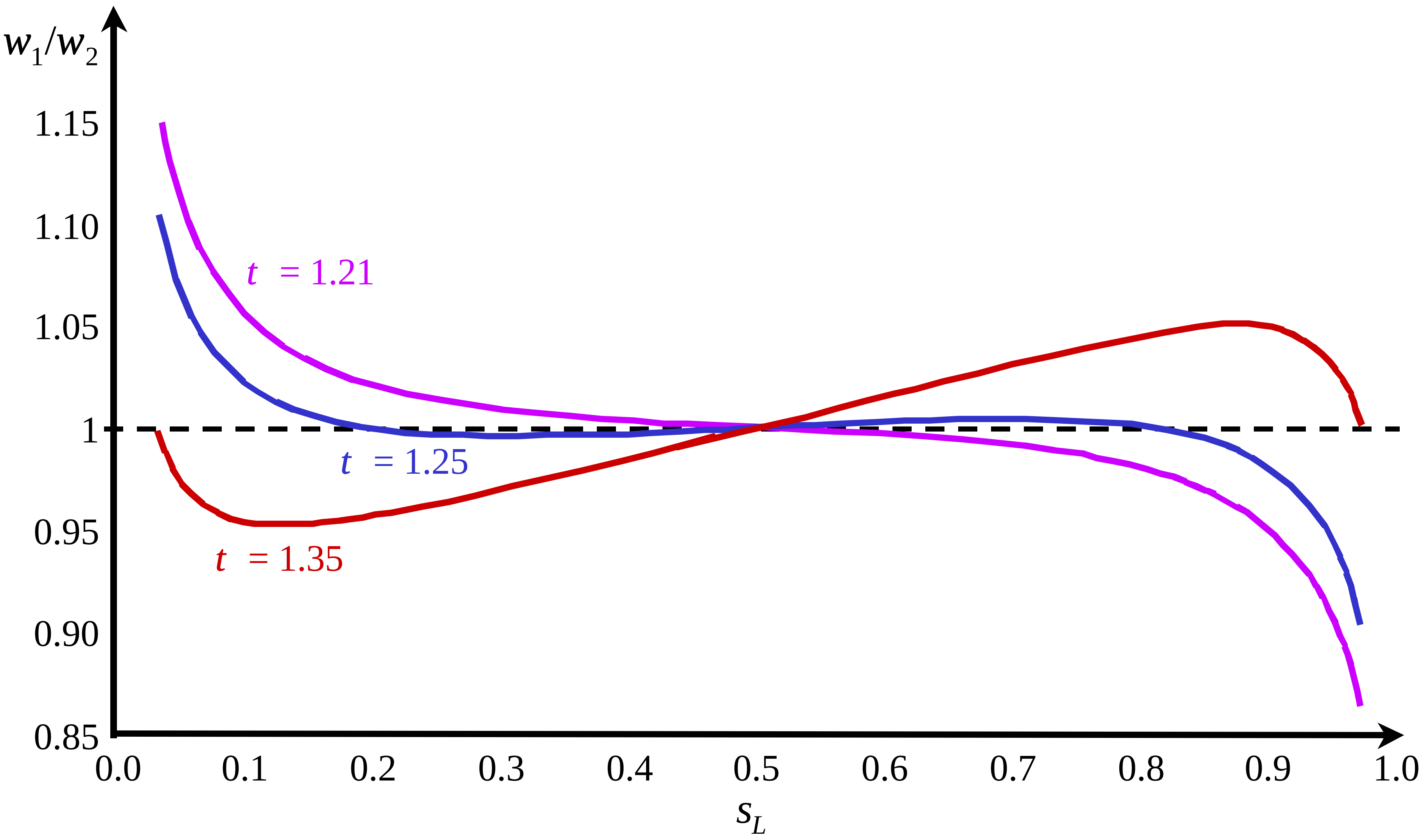
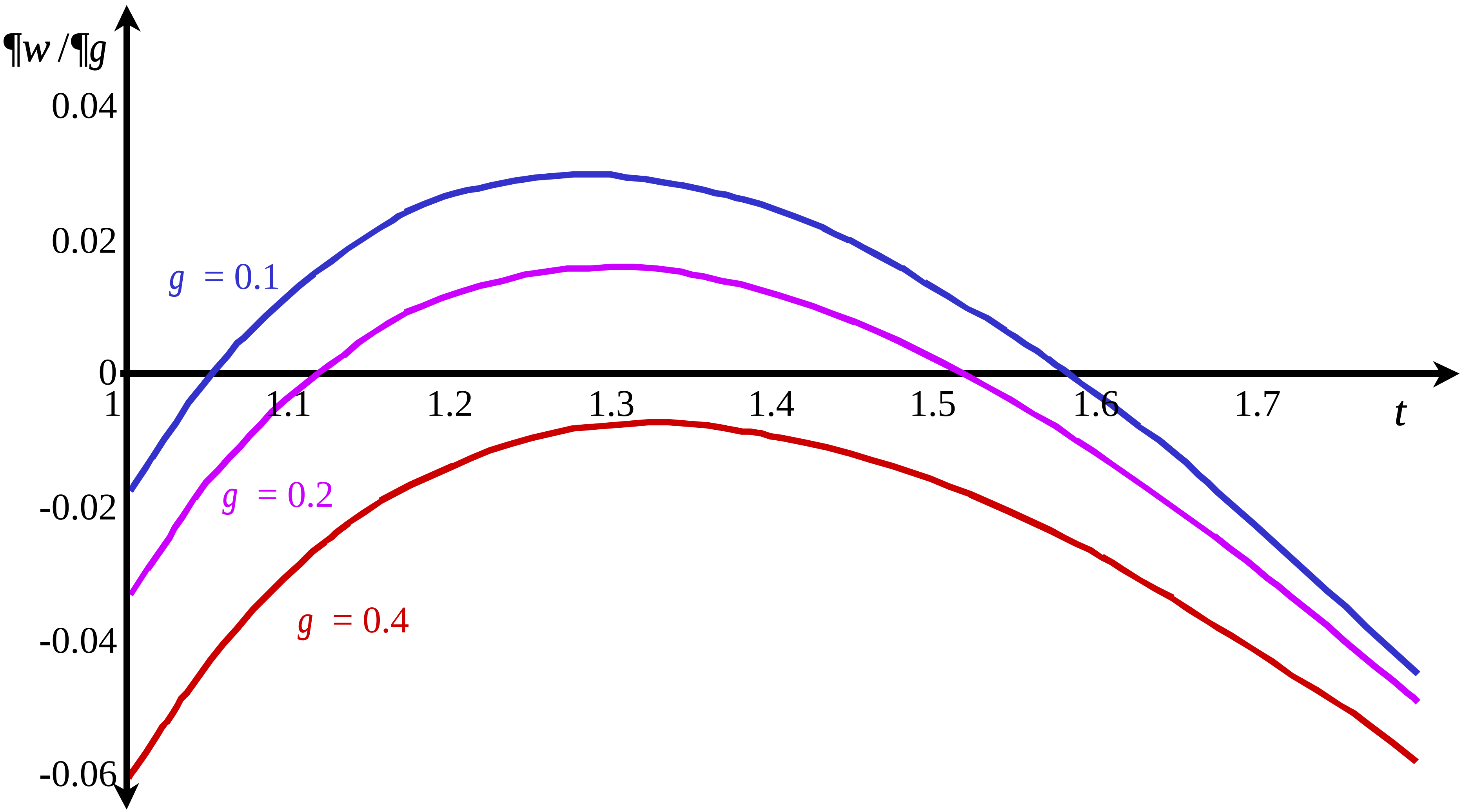


Figure 1. Qualitative Structure of Equilibria with Manufacturing Sector



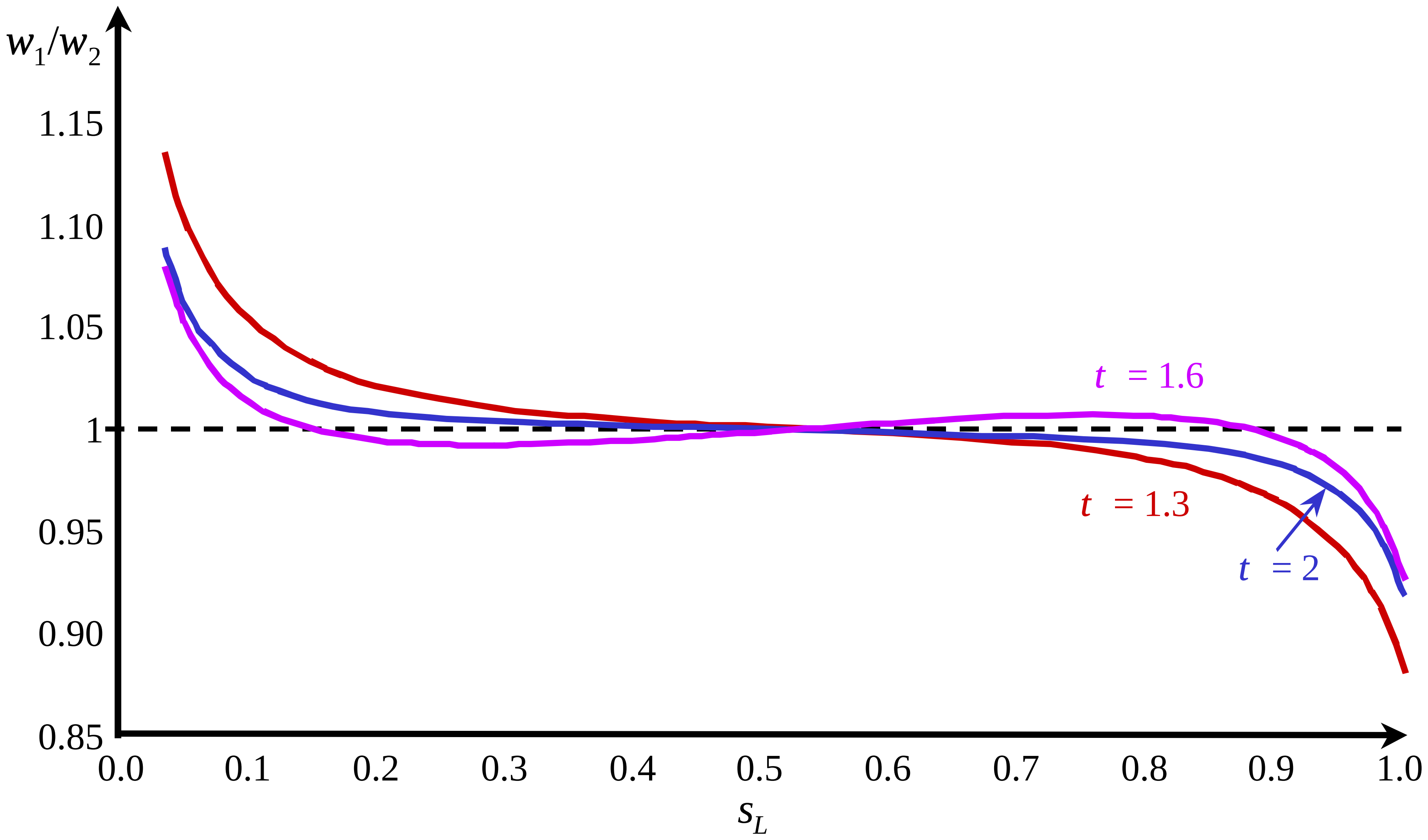
parameter values: s = 4, g = 1, d = 1

Figure 2. The Effects of Trade Liberalization on Location



parameter values: s = 4, g = 1, m = 0.3

Figure 3. The Effects of Trade Liberalization on Stability



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

Figure 4. The Effects of Trade Liberalization on Location with Agricultural Sector

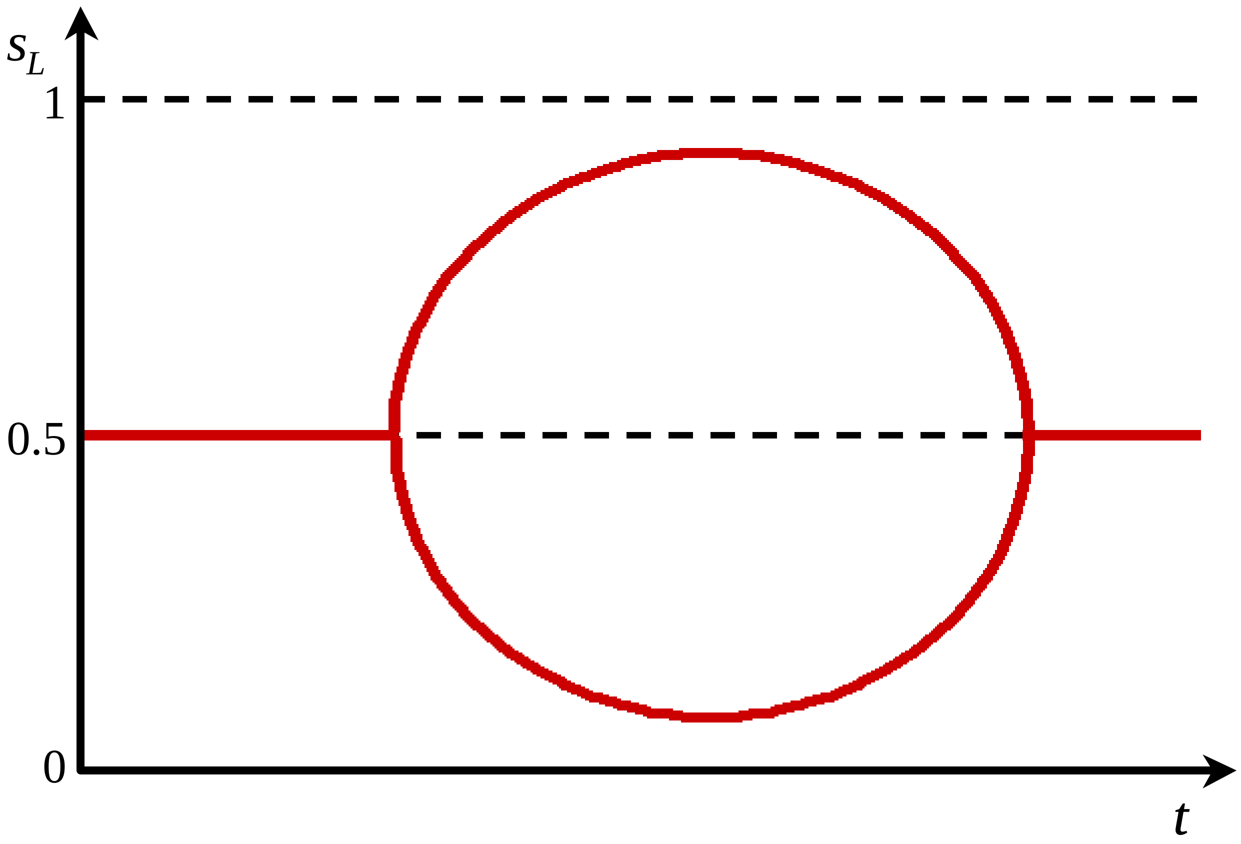


Figure 5. Qualitative Structure of Equilibria with Agricultural and Manufacturing Sectors